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Journal

—OF THE—

American Ceramic Society

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

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JOURNAL
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EDITORIALS

THE MANUFACTURER AND THE RESEARCH CHEMIST

The research chemist is like the guide and hunter of a camping party of city men. When the meat supply gives out they expect him to supply game. They have no judgment of the training, observation, caution, patience, required for the job, all of which may prove futile—if the game is not there. All his employers know is that he gets his wages and that they want their grub.

Nothing is certain for the hunter and the chemist but the law of chance. And still the former made the front of America's settlement for three hundred years and for three thousand miles. The latter has made the greatest industries of the last fifty years and transformed most smaller ones.

The hunter and the chemist can only be appreciated by their own kind. The public can know nothing but results.

What then is the problem of the manager? He knows what problems he wants solved. But neither he nor the chemist knows in how far they are soluble. The most troublesome may prove ridiculously easy. An apparently slighter one may not be accomplished without upsetting the practice of the industry, which the manager will not face, after the chemist has spent years on the proof.

Let us illustrate. The pigment called "Prussian blue" made in England was superior in quality to that of German makers

There was no trade jealousy and the English colormen invited the Germans to send a practical man to view their process. He went, saw everything and reported that the processes were identical. He added, casually, that the English had very poor equipment, especially in their mills. Liebig went to England on a scientific mission. He had tried his hand on Prussian blue for his countrymen and bearing the problem in mind visited the English works while in the country. When he returned, his former clients asked him if he had gotten any light on English Prussian blue. "Why yes," he said, "I'll show you." At the factory he grabbed up a handful of rusty nails and proceeding to the mill where a batch of pigment was grinding threw them in. The result was brilliant. What, to the practical color-maker, was a poor mill, was to the mind of the chemist something more.

Again, a certain faience factory in America knew they could distance all competitors with true turquoise, lilac, violet and ruby-red enamels. A chemist was engaged and in a reasonable time produced colors over which the directors were jubilant. Success, however, was dependent on short, fire glazing. The manager was hide-bound in refusing to make them, other than in the regular glost-kiln run. The chemist's time and much expense were long incurred in attempting to tie results to an impossible condition, long after it was demonstrated to be chemically inconsistent. The colors have never been produced in America, the manager's "practicalness" was the obstacle.

There is more to the Liebig story than a chemical mind and a simple solution. And in this "more" lies our parable. Liebig had great respect for the man with the poker—traditional practice, epitomizing experience, to the meaning of much of which the college man is commonly blind. Liebig would never attack a problem, with which he had not acquired full practical familiarity from the workmen. Chemical knowledge to him was for illuminating and improving practice, which he was painstaking to learn. The student of chemistry, even when trained in a school of ceramics or any other specialty, is dominated by chemical reasoning and methods and hardly realizes how much is locked up in traditional practice and manipulation. To the student in ceramics, Seger's study of Japanese porcelain should

be impressive, science groping after empiric achievement. Any one prompted to study Chinese porcelains will realize how much is still before us in the same direction!

Our word to the manufacturer then is, if your new chemist asks to spend most of his initial time in shop work, regard it as a mark of intelligence, not of doubt. If your directors begin to get cold feet over his salary and immediate lack of results, and some of them surely will, read Carnegie's address at the opening of the new chemical laboratory of Stevens Institute and fortified by his early faith in the chemist make them stay put.

To the chemist, beginning a new job, we would say, demand the right to work and observe in the shop. Formulate your own questions and initial points of attack. Do not let a pressing defect force you to concentrate first and exclusively on it, simply because it is pressing. The road may be too long and obscure. Minor defects cured will win your spurs and strengthen your backing. Experience gained and incidental observations made often prove a longer lap in reaching the major goal than direct reasoning and experiment.

ORIGINAL PAPERS AND DISCUSSIONS

REPORT OF THE COMMITTEE ON DEFINITION OF THE TERM "CERAMICS"[1]

To the American Ceramic Society:

Your Committee on "Definition of the Term Ceramics" submits the following report:

1. Dictionary Definition

As the initial step in its investigation of the topic assigned to it, your Committee brought together the definitions of the terms "ceramics" and "ceramic" as given by a number of English dictionaries. These definitions are reproduced below in Appendix A. From these definitions the following conclusions may be drawn: (1) The word "Ceramics" first appeared in the English language about the middle of the 19th century apparently through adoption from the French (Fr. *Ceramique*). (2) In accordance with modern literary usage, as known to the lexicographers, the term "ceramics" is employed to designate that portion of the plastic arts which embraces the production and decoration of all objects formed by the molding, modeling and baking of *clay*. According to the lexicographers the term is, therefore, practically synonymous with *clay working* or the art of the potter, and there is no indication in any of the dictionary definitions, of a broader significance than this.

2. Technical Usage

As used in modern technology, the term "ceramics" has acquired, at all events in this country, a much wider significance

[1] Received Feb. 27, 1920. Presented to the Society at the Philadelphia meeting and adopted as read.

than that indicated by the dictionary definition. This is illustrated (1) by the range of activities covered by the American Ceramic Society, (2) by the constitution of departments of ceramics in American universities and by the courses of study offered by them, and (3) by the range of material which one finds presented to their readers by American publications in this field.

The duty of this Committee, as conceived by its members, is to determine as far as possible, whether such a wider usage of the term can be justified on etymological grounds or on the grounds of expediency, or both, and on the basis of the results of its investigation to recommend a definition for official adoption by the American Ceramic Society. In undertaking this task the Committee realizes that ultimately it is always usage which will determine the meaning of a word, and that if the American Ceramic Society could bring about a general usage in accord with the broader significance referred to above, this usage would eventually determine the definition of the term regardless of any barbarisms or violations of etymology which such a broader significance might involve. Nevertheless, it is desirable whenever possible, without making too great a sacrifice of convenience, to avoid attempting to establish a definition which clearly constitutes a barbarism or a violation of etymology and historical usage. That this aspect of the matter is one deserving of consideration was also emphasized by the publication, a few years ago, of a paper by Professor Mellor on "The Origin and Meaning of the Term Ceramic" [*Trans. Eng. Ceram. Soc.*, **16**, 69 (1916)]. Judging from the tone of this paper, Professor Mellor seemed at that time to feel that the more extended definition of the term could hardly be justified either on etymological grounds or on grounds of custom or expediency, although in the closing sentences of his paper, he suggested that it might be convenient to adopt such a wider definition at some future time. In view of the importance of the points raised by Professor Mellor, it seemed to your Committee that some further study of the etymological evidence could profitably be made, especially since the Committee assumed that, before any final action was taken by the Society the matter would be brought officially before our fellow workers in England and an attempt made to secure international agreement in usage.

3. Etymology of the Term

From the dictionary definitions displayed in Appendix A, it will be seen that three etymologies for the term "ceramics" are suggested. One of these derives the term from the Greek "*keramos*," which is variously defined as "a potter," "the potter's clay," "a piece of pottery," "earthenware," and so forth, the second connects it with the Greek *kera* (wax), doubtless owing to the plasticity exhibited by clay; while the third derives it from the Greek "*keras*," a horn, which was used in early times as a drinking cup. Only the first of these three derivations seems to have been approved generally by the lexicographers (cf. Oldfather, Appendix B), and it will be noted that the meaning which they ascribe to the English term is strictly in accordance with the meaning which they assume to have been possessed by the Greek "*keramos*." In other words, the lexicographers in formulating a definition of the English word, have apparently attempted to do nothing more than simply to translate the definition of the Greek term into English.

Not feeling satisfied with the information which the lexicographers give concerning the etymology of the word, your Committee thought it desirable to have a more careful study made of this aspect of the question, and it accordingly requested Dr. W. A. Oldfather, Professor of Classics in the University of Illinois, to undertake a research upon the etymology and significance of the Greek word from which our term "ceramics" is derived. Professor Oldfather, who has devoted some special attention to the development of the arts and manufactures of Ancient Greece, is qualified to speak with authority on this question, and the Committee has been very fortunate is securing his assistance. Professor Oldfather's findings are contained in his report which is attached hereto as Appendix B.

This report brings out the following facts: (1) The Greek word "*keramos*" from which our term "ceramics" is derived is related to an older Sanskrit root, meaning "to burn," and as used by the Greeks themselves its primary meaning was simply "*burnt stuff*," that is, the *fundamental idea* contained in the word was that of a product obtained through *the action of fire* usually upon

earthy materials. Professor Oldfather shows very clearly, moreover, that it was the process rather than the materials themselves which was the predominant element in the meaning and usage of the term as employed by the Greeks and that only secondarily, if at all, the term also came to designate their chief raw material, that is, clay. While it is probable that the Greeks themselves had no knowledge of the original source of the word, it is evident that their idea of the content of the term was strictly in accordance with the Sanskrit root to which it is related, and that only later by a natural association and extension, was the word ever, if at all, used to designate the raw material of the potters art.

It seems, therefore, clear that in defining the Greek word as signifying *merely* the potter's clay or the potter's art, the lexicographers have failed to sense fully the primary meaning of the term as used by the Greek themselves and that if a fuller translation of the term were given, this translation would not be in any way at variance with the wider significance which the American Ceramic Society is accustomed to attach to the term "ceramics;" that is, no barbarism or violation of original usage will be committed if the term "ceramics" be defined so as to include a much greater variety of industries than merely the clay working industry. Rather such an extended definition would be more in accordance with the origin and historical significance of the term than is the present restricted definition found in the dictionaries.

4. The Ceramic Industries

In general, the usage of the term by the Greeks may be said to involve the two characteristic elements, first and primarily, a product in whose manufacture a high temperature treatment is involved, and second and secondarily, a product customarily manufactured entirely or chiefly from raw materials of an earthy (as distinguished from metallic, organic, and so forth) nature. It is also clear that it is these very elements which also characterize the significance of the term "ceramics" as it has come to be employed by the American Ceramic Society and in accordance therewith we may, therefore, properly define and describe the ceramic industries as those industries which manufacture products by the action of

heat on raw materials, most of which are of an earthy nature, while of the constituents of these raw materials, the chemical element silicon together with its oxide and the compounds thereof (the silicates), occupies a predominant position. In accordance with this definition we may enumerate among the products of the ceramic industries the following:

(1) All kinds of burned clay products, such as stoneware, earthenware, brick, tile, sewer pipe, terra cotta, china, porcelain, and so forth.

(2) Cementing materials, such as Portland cement, dental cements, lime, plaster, and a variety of magnesia and gypsum products whose constituents are of an earthy nature and which, after a preliminary treatment which involves a calcination, acquire the property of "setting" to a greater or less extent, when mixed with the proper liquids.

(3) All varieties of glass and glassware including quartz glass, glazes, enamels and many of the artificial precious stones.

(4) Enameled metal products, where the enamel itself is a ceramic material applied to the metal at high temperature, the metal serving only as a skelton to give the desired form and strength to the glass which it supports.

(5) Refractory articles or materials, either wholly or partially composed of or manufactured from clay, silica (in its various forms), alumina (bauxite), magnesia (magnesite), lime, chromite, asbestos, zirconia, mica, the rare earths, certain carbides and nitrides, and in general any non-metallic product capable of withstanding elevated temperatures. In the case of all products of this class it is evident that a high temperature treatment is fundamental.

(6) Abrasive materials such as carborundum, alundum, and zirconia (and by association, finely divided silica and emery), together with the products manufactured from them by bonding with an earthy material.

(7) Various electrical and thermal insulating products in the manufacture of which earthy materials enter as an important element.

5. Ceramic Chemistry

Of the sciences underlying the ceramic industries, chemistry probably occupies the most important position, and with the

exception of physiological chemistry (? plumbism) and possibly also organic chemistry, practically all of the branches of the science itself find important applications in ceramics. It would, however, be inappropriate to employ the term ceramic chemistry to designate the sum total of chemical facts and laws which are made use of in one way or another in connection with ceramics. Thus, for example, the mere fact that colloid chemistry finds important applications in connection with the ceramic industries would not justify its inclusion under such a term as ceramic chemistry since it properly belongs to the branch of the science known as physical chemistry. A similar situation of course exists in connection with other lines of chemical technology. Thus, for example, in the technology of dye manufacture the branch of chemistry, known as organic chemistry, occupies the foremost place, but important applications of physical chemistry, analytical chemistry, and inorganic chemistry, are also made in this field.

If, therefore, we are to employ the term ceramic chemistry to designate a branch or field of the science it must be upon some other basis than merely the sum total of all chemical facts and laws which may find application in ceramics. It seems to your Committee that there are good reasons for employing the term to designate a branch or field of the science of chemistry and it proposes to define the term ceramic chemistry as *the chemistry of the compounds of silicon* in a somewhat similar way to which the term organic chemistry is employed to designate the chemistry of the compounds of carbon. The element silicon and particularly its oxide and the compounds derived therefrom (the silicates) occupy a characterizingly predominant position in connection with the ceramic industries. Practically all of the products of these industries involve in one way or another the chemistry of this element. It is true that the well trained ceramic chemist must also be familiar with the chemistry of related compounds, such as the other refractory oxides, for example, but a similar statement is also true of the well trained organic chemist who must also know a great deal of chemistry other than the chemistry of the compounds of carbon. In restricting the term ceramic chemistry therefore to the chemistry of the compounds of silicon there is no intention of conveying the impression that

this is all the chemistry the ceramic chemist needs to know, but rather such a definition of the term delimits a self-contained and definite branch of chemistry of primary and fundamental importance to all of the ceramic industries. To the ceramic chemist this branch of chemistry occupies the same position in importance that organic chemistry does to the chemist who is an expert in any of those branches of chemical technology ordinarily classed as the organic industries.

It may appear at first sight that in one respect the above definition is too broad since there are many compounds of silicon (such, for example, as the halides, sulfides, hydrides, and nitrogen compounds, as well as others involving two or more of these classes of elements) which do not at present find any particular application in the ceramic industries. It is obvious that the portion of the chemistry of silicon which deals with silica and the silicates is the most important part of the subject for the ceramic chemist and the point in question here is thus rather one of emphasis than of inclusion or of exclusion.[1]

It is thus true that the man who studies the chemistry of silicon from the point of view of ceramics will devote *most* of his time and attention to silica and the silicates, but for a well rounded training he should of course also know something about the other branches of silicon chemistry. The recent attempts to remove iron from ceramic materials and products by treatment with such gases as chlorine and phosgene indicate that some knowledge of the chemistry of the halogen compounds of silicon is not by any means a valueless one for the ceramic chemist. Again, the possible utilization of certain slags in manufacturing cements and other ceramic products also suggests the possible importance of a knowledge of the sulfur compounds of silicon. Similarly the carbides, nitrides, and carboxides obviously are important in connection with the preparation of certain electric furnace products, such as carborundum, monox, siloxicon, and so forth. It seems to your Committee, therefore, entirely appropriate to define the term ceramic chemistry in the above manner.

[1] As is similarly the case in organic chemistry where the well trained organic chemist is expected to have a reasonable degree of familiarity with many organic compounds which do not at present have any industrial importance.

At the present time the chemistry of the compounds of silicon which is included in the training of the average chemist is only the comparatively small amount which he obtains in his general course in inorganic chemistry. In this respect the chemistry of this element occupies a similar position to that occupied by the chemistry of carbon previous to the recognition of organic chemistry as a sufficiently important and self-contained portion of the subject to be recognized as one of the larger branches of the science. It seems to your Committee that the time has come to give a similar recognition to the chemistry of silicon and in the case of those chemists primarily interested in the applications of chemistry to ceramics, to expect that they will devote to the study of this branch the same degree of time and attention that is devoted to organic chemistry by those who expect to make considerable use of that branch of the science. In educational institutions having departments of ceramics, this will naturally mean that the administration of specialized instruction in this branch of chemistry will be under the direction or guidance of this department, since without the presence of a body of students interested primarily in ceramics, there will ordinarily not be any demand for instruction in this field other than the relatively small amount given in general courses in inorganic chemistry.

6. Ceramic Engineering

If it seems desirable to propose here a definition for the term ceramic engineering, it is clear from the foregoing that such a definition would amount to substantially the following: Ceramic Engineering is that branch of engineering which deals with the applications of science to the ceramic industries.

7. Conclusions

In concluding this report on the subject assigned to it, your Committee wishes to urge the importance of the essential unity implied in the usage of the term "ceramic industries" in the sense proposed above. All of the industries named in Section 4 are fundamentally so closely allied to one another that a recognition of this unity, of the nature of the bonds, and of the close cooperation which such unity should bring about is of the greatest

importance to the future development of these industries and to the further progress in the underlying sciences which such development requires. As already pointed out, the chemistry of silicon is common to practically all of these industries. This is also true with respect to the field of high temperature chemistry or pyro-chemistry as it has been called, and it is only through our comparatively recently acquired knowledge of how to produce, control and measure high temperatures in the laboratory, that the modern advances in our knowledge of high temperature processes have been made possible. Moreover, the material "clay" is utilized in one way or another to a greater or less degree in connection with nearly all of the ceramic industries. It seems, therefore, to your Committee that the elements possessed in common are so fundamental in importance that these industries should and will recognize their essential unity and will establish that coöperation of effort which this unity implies and which will prove to be a source of great strength in their future development. It is fortunate indeed that the American Ceramic Society includes all of the classes of industries listed in Section 4 and it is to be regretted that our fellow-workers in England have not thus far seen fit to unite similarly in single technical organization.

To the end that suitable official action be taken with regard to defining the term "ceramic," your Committee makes the following recommendations: (1) That the American Ceramic Society approve tentatively the definitions proposed in this report. (2) That copies of this report be transmitted to the officers of the English Ceramic Society and to those of the English Society of Glass Technology with the request that these societies take such action with regard thereto as seems to them appropriate. (3) That after the receipt of reports of the actions taken by these organizations, the American Ceramic Society then proceed to officially adopt definitions of the terms in question.

While the matter referred to your Committee has to do primarily with the meaning to be attached to an *English* word and consequently only this country and the British Empire are necessarily involved, it should be pointed out that substantially the same term is used in the French (ceramique), in the Spanish and Italian

(ceramica), in the Scandinavian, Dutch and to a less degree in the German (keramik) languages also, and that our fellow-workers in some of these countries may be interested in considering the same question with reference to the usage of the term in their languages. This may, however, not be true in the case of Germany, owing to the very extensive and successful propaganda in that country directed toward the abandonment of words of foreign origin. It is, therefore, suggested that copies of the report be sent also to any ceramic societies which may exist in the above named countries, with the exception of Germany.

E. W. WASHBURN
H. RIES
A. L. DAY

APPENDIX A

Definitions of the Words "Ceramic" and "Ceramics"

The Century Dictionary and Cyclopedia, 1911

Ceramic, keramic: (Gr. *keramos*, potters' clay, a piece of pottery, jar, etc.). Of or belonging to pottery or to the fictile arts; pertaining to the manufacture of porcelain, stoneware, earthenware, and terra cotta: as *ceramic* decoration.

Ceramics, keramics: The fictile arts collectively; the art or industry of making jars, vases, etc., from clay which is molded and baked; also, collectively the things so made.

Murray's English Dictionary, 1893

Ceramic, also keramic: (ad. Gr. *keramikos*, of or for pottery, *keramike*, the potter's art, pottery, f. *keramos*, potter's earth, pottery). 1. Of or pertaining to pottery, esp. as an art. (Not in Craig, 1847.) 1850 J. Marryat *Pottery and Porc. Introd.* The Plastic or Keramic (ed. 1868 Ceramic) Art. 1862 Thornbury *Turner* I 245. About 1775 Mr. Wedgwood began to introduce high art into ceramic manufacture. 1879 Academy 38 Imitations of ancient ceramic work. 2. As sb. in pl. The ceramic art, the art of making pottery. 1859 Gullick and Timbs *Paint.* 30 Writers on ceramics. 1879 *Academy* 38 (*Article*) Recent Ceramics.

Richardson's New English Dictionary, 1858

(Not given)

American Encyclopedic Dictionary, 1896

Ceramic: (Greek, *keramikos*—pertaining to pottery, *keramos*, a potter). Of or pertaining to pottery, or the art of pottery.

Ceramics: All the varieties of baked or burnt clay. It is distinguished from vitrics, in which silex predominates, the result being glass.

Webster's New International Dictionary, 1918

Ceramic: (Properly pronounced *keramik* only when spelt with k.) (Gr. *Keramos*, earthenware.) Of or pertaining to pottery; relating to the art of making earthenware; as *ceramic* products.

Ceramics: 1. Art of making things of baked clay, as pottery, tiles, etc. 2. Articles formed of clay in whole or in part and baked, as vases, urns, etc.

Jervis' Encyclopedia of Ceramics, 1902

Ceramic: The designation of the potter's art and its production. It is probably derived from a Greek word, "kepac" a horn, which was used in early times as a drinking cup. The son of Bacchus and Ariadne was Keramos, the patron of potters, which gives the supposition an air of reality.

New International Encyclopedia, 1902–1914

Ceramic: (Fr. Gr. *keramos*, potter's clay.) A term used to designate the department of plastic art which comprises all objects made of clay, including terra cotta, porcelain, and all other forms of pottery.

The Americana, 1918

Ceramics: The fictile art; the art of the potter. The word ceramics is derived from the Greek *keramos*, the potters clay. The subject "ceramics" can be primarily divided into two basic divisions: (1) the technique and (2) the product.

Encyclopedia Britannica, Eleventh Edition

Ceramics: (Gr. *keramos* earthenware.) A general term for the study of the art of pottery. It is adopted for this purpose both in French and German and thus has its convenience in English as representing an international form of description for a study which owes much to the art experts of all nations, although "ceramic" and "ceramics" do not appear in English as technical terms till the middle of the 19th century.

Funk and Wagnalls' Standard Dictionary, 1917

Ceramic: Of or pertaining to pottery (including porcelain and terra cotta), or its manufacture, fictile art, or ceramics in general. "The ceramic art is the art of manufacturing objects of all sorts, in every kind of clay, and of decorating them by means of painting or modelling, or both." Adeline *Art Dictionary*.

Ceramics: (Gr. *keramikos, keramos*, potters' clay.) 1. That department of plastic art which includes the production of all objects formed by molding, modeling, and baking clay, such as vases, bas-reliefs, cornices, cups, articles of porcelain, terra cotta, and pottery in general; fictile art. 2. pl. The objects so made.

Nuttall's Dictionary of Scientific Terms, 1878

Ceramic: (Gr. *kera*, wax), denoting the plastic arts; a term frequently applied to ornamental pottery.

Simmonds' Commercial Dictionary of Trade Products, 1892

Ceramic: A term often applied to ornamental pottery.

A NOTE ON THE ETYMOLOGY OF THE WORD "CERAMIC"[1,2]

By William A. Oldfather[3]

The word "ceramic" is a transliteration from the Greek adjective *keramikos*, which is derived from *keramos*, a general term designating the product (and perhaps also, although apparently later, if at all), the material of the potter's art. One who produces *keramos* was called a *kerameus*, and from the *kerameis* (plural of *kerameus*), the district in Athens about the Dipylon gate received its name, *Kerameikos*, that is, the "quarter of the potters." Keramos, worshipped by the potters at Athens [Philochoros in Harpokration, s. v. *kerameis*, and thence in Suidas, s. v. *keramis*, a son of Dionysos[4] and Ariadne (Pausanias, 1, 3, 1)], is merely an eponymous hero of the common type among the Greeks, that is an obvious personification from the noun *keramos* itself, and can throw no light either on the origin or proper meaning of that word, which must be determined by the facts of usage and etymology.[5]

Now *keramos* is used of articles made exclusively or ordinarily out of clay by the process of *burning* (*e. g.*, sun-dried bricks[6] would not be called *keramos* or any other related word).

[1] Received Feb. 27, 1920.

[2] Constituting "Appendix B" of the Report of the Committee on the Definition of the Term "Ceramics."

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[4] For a suggestion as to possible reasons for the selection of parentage, see the article *Keramos* in W. Roscher: *Ausführl. Lex. der griech. u. röm. Mythol.*

[5] The suggestion that *keramos* means "horn" (keras), that is originally a "drinking horn" (Larousse: *Grand Dict. Univ.*, s. v. *ceramique;* repeated in the *Nouveau Larousse Illustré;* also Boccardo: *Ency. Ital.*, s. v. *ceramica*) cannot be taken seriously, since there is nothing in the attested usage of either word to favor such a connection, and it is altogether improbable that the first characteristic employment of pottery was in this particular shape or solely for this purpose. The appeal to the word *pot* as derived from Lat. *poto* is useless, because the etymology of this word is not certainly known.

[6] It might be noted in passing that the verb kerameuo was used of brick-making. Pollux, 10, 175.

That the *process* and not the *material* is the most characteristic feature, would seem likely from the further fact of usage that the Greeks often employed other words for "clay," that is, *pēlos* (lit. "mud"), *gē* (lit. "earth"), *argīlos* or *argillos* (lit. "white stuff," "white clay"), *keramis* or *keramitis* or *keramike gē* (lit. "pottery earth"), or simply *keramis* (with the word *gē* perhaps understood),[1] while *keramos* is very rarely, if ever, used in this sense. For not all the instances given by lexicons and commentaries for this meaning of *keramos* stand the test. Thus, to take the earliest instance cited by Stephanus in the *Thesaurus Linguae Graecae*, the phrase "the Attic *keramos*" quoted from Kritias (late 5th century), as preserved in Athenaios, 1, 28 C, unquestionably means "pottery;" the sentence which Stephanus quoted from Pollux, 7, 161, is mistranslated, its real meaning, as Joachim Kühn has pointed out, being: "And *keramos* is also used of the whole mass (or class) of vessels made of clay;"[2] in Plato, *Tim.*, 60 C and D (a sentence too long and difficult to quote here), although *keramos* has very generally been taken to mean "clay," there can be no doubt but that Jowett and Archer-Hinds are right in translating it "pottery" and "earthenware" respectively; in Aristotle, *On Colors*, 1, 6, the older Latin versions (*e. g.*, in the Berlin and the Didot editions) which translate *keramos* with *fictile*, "earthenware," are probably right on the general principle of preferring the well established meaning of a word, although "clay" would make as good sense in the context; again, in Aristotle, *Meterology* iv, 3, 9; 6, 6 and 7, "earthenware" would fit the context perhaps as well as "clay," and is so given not only by the versions mentioned above, but also by so great a specialist in this field, as I. L. Ideler, while in iv, 10, 9, "earthenware" seems to be the only proper meaning, and the word is so rendered in the translations just mentioned. Only in late writers have I found the expressions "waterjars made of *keramos*" (Pausanias—late 2nd cent. A. D.—10, 1, 3), "a receptacle made of *keramos*" (Pollux-late 2nd cent.

[1] The expression *parthenios gē* ("virgin earth") used by Clement of Alexandria is a mere rhetorical flourish.

[2] Stephanus took *hyle*, "mass," in the sense of "material," which is opposed to the sense of the context. The idea which Pollus had was that of Hesychios, s. v. *keramos*, who defines it as "every kind of pottery."

A. D.—6, 14) "vessels made of *keramos*" (Herodian—3rd cent. A. D.—3, 9, 10), and here it is not at all certain that *keramos* denotes "clay," since "earthenware," although the expression may be perhaps a bit illogical, is probably all that was meant.[1]

With this usage the results of etymology are in accord, for, disregarding the guesses of Greek lexicographers and the older but inadequate association with *kerannymi*, "I mix," etymologists seem to be agreed now in referring *keramos* to a primitive Indo-European base which means "to burn," as is clear from the cognate *çar*—in Sanskrit, *cremo* in Latin, and so forth (*e. g.*, A. Vaniček: *Etymolog. Wörterbuch der lat. Sprache*, 2nd ed., 67; A. Walde: *Lat. etymol. Wörterbuch*, 2nd ed., pp. 109 f.; Leo Meyer: *Handbuch der griech. Etymologie*, 2, p. 361; E. Boisacq: *Dict. etym. de la Langue grecque*, p. 436, and so forth). *Keramos*, accordingly, meant originally only "the burnt stuff." That this was normally clay or some kindred substance is, of course naturally true, but that *keramos* and derived forms were not clearly felt by the Greeks to designate the material *per se* (as we speak of "earthenware"), would seem probable from the readiness with which they applied adjectives to these words, which denote very different materials.

Thus Homer (Iliad V, 387) speaks of a "bronze *keramos*"[2] (jar); Euergos of Naxos (latter half of the 6th century B. C.) in

[1] As, for example, in Lucian, *Vera Hist.*, 2, 33, "two gates, one iron, the other made out of *keramos*," "brick," or "earthenware" is certainly meant. We might speak of a brick being "made of burnt clay," or a tile being "made of terra cotta," without committing a serious offense, and, although the expression may not be strictly logical, it is in line with the natural development of meanings in the word "make" which leads to the sense "to consist of, or be composed of" [*New English Dict.*, *Make* I, 4]. I should be inclined to justify the expressions just quoted as a natural development of the meaning of *poieo* (make) in Greek similar to that of *make* in English.—I do not claim that *keramos* never means "clay," for, of course, I have not examined all the thousands of instances of the occurrence of this word, and those that are derived from it, but the cases cited by the lexicons for this meaning are not conclusive, and, in any event, that can scarcely have been the primary meaning.

[2] A scholiast calls this a Cyprian usage, for in that dialect, he says, *keramos* meant "prison." This is obviously only an extension of the meaning "jar" or "pot" (Ebeling, Capelle, Ameis-Hentze, and so forth, *ad loc.*), and Walter Leaf pertinently compares our slang expression "jug" for the same thing.

an inscription preserved by Pausanias, 5, 10, 3, says of his father (or possibly himself) that he was the "first to make *keramos* (here—roofing tile) of stone;" Ptolemy Euergetes (3rd cent. B. C.) in his *Memoirs*, quoted by Athenaios, 6, 229 D, speaks of "silver *keramos*" (table ware) and the famous Kleopatra (1st cent. B. C.), in Athenaios, 6, 229 B, called her tableware "silver and gold *keramos*;" Polybios (2nd cent. B. C.) 10, 27, 10, speaks of "silver *keramides*" (roofing tile); Hegesander (2nd cent. B. C.) in his *Memoirs*, quoted by Athenaios, 14, 621 A, mentions a "leaden *keramis*" (here = a large jar), and Moschion (of uncertain age but probably before the Christian era), in a fragment preserved in Athenaios, 5, 207 A, B and D, speaks three times of "leaden keramides;"[1] Pausanias (late 2nd cent. A. D.) 5, 100 3, says of the temple of Zeus at Olympia, "The *keramos* (tile roofing) is not baked earth, but of Pentelic marble cut in the shape of *keramos*;" finally Saint Chrysostom, Homily 7 on the Epistle to the Colossians Ch. 3 (*Patrol.* Vol. 62, Col. 349) denounces the folly of those who "make golden *keramia*" (tableware).

Since *keramos*, therefore, meant properly "burnt stuff," and the Greeks did not restrict it and related words to clay products,[2] it might, therefore, not inappropriately be applied to related products in whose manufacture a change of physical and chemical properties under the influence of high temperatures is required. In particular the inclusion of an industry like glass-making which developed out of the potter's art and was long closely associated with it, might, by a natural extension of meaning, be included under the technical designation for that art, if, as in this case, there is involved no barbarism, either in usage or etymology. Now glass was no doubt employed first as a glaze for pottery, intended to make vessels tight and durable (H. B. Walters: *History of Ancient Pottery*, 1905, 1, p. 9), and for many centuries

[1] In the first instance "plates" or "roofing" are meant, in the second and third the exact meaning is not so clear, but it is of no consequence for the present argument.

[2] I do not think it likely that the Greeks were aware that *keramos* meant etymologically "burnt stuff." All I am concerned with is the attempt to show that to their feeling, the word did not mean "clay" primarily, but was applicable to other materials associated for one reason or another with clay products.

glazes were applied to a back-ground of pottery at a period of industrial development so simple as to make it very unlikely that anyone but the potter himself produced the glaze. This state of things existed for a long time in Egypt (W. Froehner: *La Verrerie antique*, p. 9; G. Perrot and C. Chipiez: *Hist. de l' Art, and so forth*, 1, 820ff.), and also in the Minoan civilization of Greece where faience ware, glass pastes, and so forth, were abundant for many centuries (Perrot and Chipiez: *op. cit.*, 6, 943ff.; Hall: *Aegean Archaeology*, 82, 105, and so forth), and is perhaps best illustrated in the glazed brick industry of Assyria (Froehner: *op. cit.*, 15), and especially its extraordinary development in ancient Persia (Perrot and Chipiez: *op. cit.*, 5, 816ff., 834ff., 872ff.), where brickmaker and glazier must have been the same person. Indeed it cannot be doubted that glassmaking developed out of pottery manufacture (A. Kisa: *Das Glas im Altertum*, p. 74, H. Blümmer: Article *Glas* in *Pauly-Wiss. Realencyclop.*, 7, 1382), as in some of its forms it has never been separated from it. The thin glazes upon the finest Greek pottery[1] we may be sure were made by the potters themselves, as we have inscriptional evidence for the fact in the case of one early Attic vase which bears the inscription "Oikopheles pottered me" (Walters: *op. cit.*, 1, 379). Only very gradually, from the handling of larger and larger masses of glazes and constant experimentation with them for the production of new effects in color and other qualities, did the manufacture of glass in some forms come to be definitely separated from that of pottery. Although the Greeks had known glass and glazes for centuries, no specific word for the substance in general[2] is found until early in the fifth century, when Korinna of Thebes used the adjective *hyalinos* (frg. 42, Bergk), and by the end of the century *hyalos* and *hyelos*[3] were in common use (Philolaos, Herodotos,

[1] On Greek and Roman glazes see especially H. Blümmer: *Technologie und Terminologie*, and so forth, 2, 88ff., H. B. Walters: *op. cit.*, 1, 118, 127ff., 202ff.; 2, 436f.

[2] The Homeric *kyanos* was restricted to a dark blue paste only sparingly employed. From the use of the word in later authors it would appear that the word suggested to the Greeks a color rather than a material. The etymology is unknown.

[3] Nothing is known of the etymology of hyalos (or hyelos); the guesses which have been made are not convincing.

Aristophanes, Hippokrates).[1] It is true that the Greeks, as far as I am aware, employed different words for glass, glass-maker, and so forth, and in no case used the same term to include both glass and pottery, but that may be due to the very fragmentary nature of our literary sources (practically all the technological literature has been lost), and to the circumstances that in these sources we find no instance in which the Greeks had occasion to use a comprehensive term to include both the original and the derived industries, as we do frequently under modern industrial conditions. Had they desired such a term, I see no very good reason why they might not have used *keramos*, or some derivative, to denote the complex of allied and derived industries, because of the meaning of the stem and the primacy of the potter's art, both generically and in relative importance.[2]

Certainly, in view of the numerous instances of extension and contraction of original meaning which modern languages show in the case of words derived from Greek and Latin,[3] it would appear almost pedantic to object to the extension of the word "ceramic" to cover a group of industries derived from or essentially allied to the manufacture of clay products, particularly if the technical world has already begun to employ the term extensively in this way. For it is *usus*, as Horace long ago said, *quem penes arbitrium est et ius et norma loquendi.*

[1] The expression "poured stone" (Herodotos, Plato, and so forth) applied properly to opaque glass, was never widely used, and is probably a translation of a foreign, perhaps Egyptian (W. Froehner: *op. cit.*, p. 4) term. Our expression "stone jar" might be compared.

[2] Very much as *chalkeus* (copperworker) was applied to metal workers in general, because of the primacy of work in copper.

[3] A journal does not have to appear daily, the physicists have dissected the atom (a plain contradiction in terms); bucolic is no longer restricted to neatherds; botany includes much that is not pasturage; the plumber handles more than lead; the carpenter may make other things than wagons; a horn may be made of tin; a pen of steel, and so forth, and so forth.

A HIGH-TEMPERATURE TRANSVERSE-STRENGTH TEST AS A METHOD OF TESTING SAGGER MIXTURES[1]

S. C. Linbarger and C. F. Geiger

In the manufacture of saggers to be sold for use in the various ceramic industries and in the sale of non-plastics for use in saggers it has been necessary to make tests on very many unrelated mixes. For this work it was necessary to devise tests that would tell in a short time the relative values of mixes, for it was not feasible to follow the laborious procedure of making full size saggers and determining their natural life in regular kiln runs. The life, of course, is the important item, and such a test in some instances would have a duration of years.

Large saggers for sanitary ware, and so forth, must withstand at high temperatures the severe transverse strains that often result in sagging bottoms or rupture. Warped saggers often cause complete losses of such low-bond wares as abrasive wheels and of large, heavy ware.

There have been efforts made to establish a compression load test at high temperatures on whole saggers. Theoretically this is an ideal plan, but it fails of its purpose because the result is usually a failure due to mechanical defects of the individual sagger. In this regard it is imperative to distinguish between the strength of the structural sagger and of the sagger mix. The best that can be done is to make the best possible sagger mix as determined by certain standardized tests based upon the requirements of usage; then it is safe to assume that from the best mixes the best saggers can be obtained.

Tests Employed

In connection with the tests on commercial sagger mixes an extensive research was conducted on the sizing of the grog and on the substitution of other non-plastic refractories for the grog.

[1] Received Feb. 27, 1920.

In this latter work more complete tests were made, and these were arranged so as to give mathematical results as far as possible. Such conclusions shall be presented as the completed tests warrant.

The softening points of the clays were determined, and vitrification behavior was ascertained in a general way from briquettes of the individual clays burned to cone 12; otherwise the tests were all limited to the burned trial pieces of sagger mix. Cracking propensities and strength in the dry state were readily revealed on examination.

The following are the tests chosen for standardization: (1) Transverse strength test at 1300° C. (2) Repeated heating tests. In addition, the adsorptions were determined and transverse strength tests of the burned pieces in the cold state were made on a 10,000 pound testing machine. Usually, however, an examination of a burned sagger will tell whether or not the mix is of sufficient strength for handling, and the last test by itself is of little value. The results of the four tests were considered with a view of discovering any correlations that might exist.

We are of the same opinion as J. B. Shaw, who has emphatically stated that for most purposes high temperature load tests should be carried to ultimate failure of the piece tested rather than only to some arbitrary stage of deformation. The transverse strength test at high temperatures was devised in preference to modifying the compression test as described by either Bleininger and Brown, Shaw, or Schurecht in the Transactions and JOURNAL OF THE AMERICAN CERAMIC SOCIETY, because the former embraces elements of compression, tension, and shear and apparently effects strains very much like those to which saggers are subjected both in handling and in the kilns.

After some preliminary experimenting the green test-piece size for all tests was set at $8 \times 2^1/_2 \times 2$ inches. This gives a very sturdy piece and is much more likely to allow of checking of results than the smaller test pieces usually adopted. The size of trial piece for mixtures of this kind is an important consideration because coarse grog will cause cracking of small pieces, which in themselves are difficult to form with any degree of perfection. The mixes were worked to a good plastic condition and aged in

moist cans for a few days, and the pieces were formed by ramming in a wooden mould. The firing to cone 12 was always done in commercial sagger kilns.

The burned blocks were ground down on disc grinders so that the outer clay skin was removed from the two broad faces, which were at the same time made flat and parallel. The pieces were then approximately $2^3/_8 \times 1^7/_8$ inches in section. The measurements were in all cases calipered to the nearest sixty-fourth of an inch.

The transverse strength tests at 1300° C were made on a 6-inch span with the load applied in the center. The furnace is very similar in size and design to that recommended by the American Society for Testing Materials for load testing of fire brick. Fig. 1 shows the exterior of the kiln and the arrangement for applying

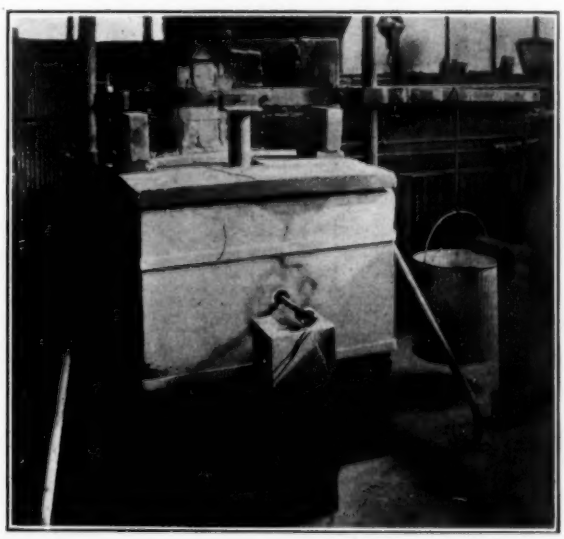

FIG. 1.—Furnace used in determining transverse strength at high temperatures.

the load. The lever arms have a three to one ratio, so that any given load in the pail has a direct effect of three times as much on the test piece.

Fig. 2 is a diagram of the interior furnace setting. From the beam, which is made of two strips of $2^1/_2 \times {}^3/_8$ inch bar-iron bolted together and which can be raised and lowered by a bolt and thus be maintained horizontal, the load is transmitted to a tall carbofrax cylinder, *A*, which rests on a carbofrax prism, *B*, which in turn is centered crosswise on the test piece, *D*. The latter is supported on two smaller carbofrax prisms, *E*, which rest on a solid brick setting. The bearing edges of the three prisms are slightly rounded. The test piece is surrounded by a carbofrax ring or muffle, *G*, so that it is not touched by the direct flame. This precaution is very important as will be noted later.

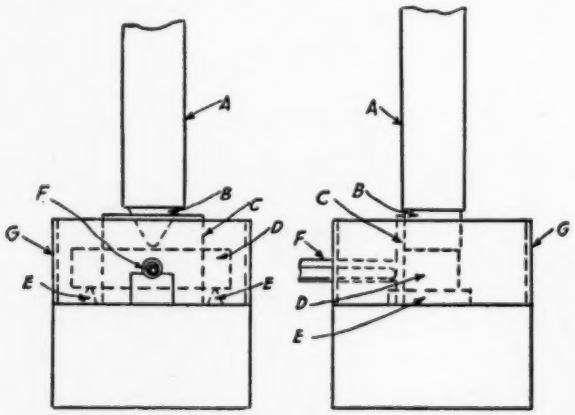

FIG. 2.—Diagram of interior furnace setting.

In contact with the test piece is a carbofrax slab, *C*, about ${}^3/_4$ inch thick, which acts as a stop for the heavy cylinder when rupture occurs and prevents damage to thermocouple tubes. Against this slab, which is of very high heat conductivity, is set the end of the thermocouple tube, *F*, containing a platinum couple. In this way the thermocouple is only ${}^3/_4$ of an inch from the test piece and in effect is in direct contact with it. The temperatures are taken on a recording pontentiometer.

For every test run a definite standard heating curve is drawn on the recorder paper with a template. This curve is followed very closely. The total time of heating up the furnace is 3 hours.

After a holding period of 45 minutes the temperature is still maintained constant and the applying of the load to the test piece is started. This is accomplished by pouring $^1/_4$ and $^3/_8$ inch ball bearing culls from a measure that holds just one pound into the V trough, which is about ten feet long. This conveys them in a steady stream to the pail suspended from the lever beam. The load is applied in this manner at the rate of two pounds per minute, which results in an effective increase on the test piece of six pounds per minute. This is continued until rupture occurs. The furnace is then shut off, and the balls are weighed. This weight is multiplied by 3 and added to the effective weight of the lever and the weights of the loading bar and prism.

From this total and the size of the section of the piece, the modulus of rupture in pounds per square inch is calculated from the formula $M = \frac{3Pl}{2bd^2}$, in which P is the breaking load in pounds, l is the length of the span in inches, and b and d are the width and depth, respectively, in inches.

Considerable experimenting was necessary to establish a repeated heating test that could be completed on the best mixes in from three to four weeks and yet would not be too severe on poorer mixes. The question then arose as to when a test piece was to be considered as having failed. It was decided to apply a cold transverse strength test after each heating and to declare a failure when a piece had become so weakened that its modulus of rupture fell below 200 lbs. per square inch. This, of course, is an entirely arbitrary figure and possibly is too low. The number of heatings withstood gives the numerical factor for a given mix under this test.

The first tests were made upon pieces that were set upon the muffle and heated up in the load test firings. This method proved inadequate because the trials were exposed to the direct oil flame and failed in 12 heats, whereas, when muffled and subjected to the same rates of heating and cooling they were apparently unaffected in twenty heats. It would not be possible to set groups of trial pieces so that they could be uniformly exposed to an impinging flame, and hence modification of the test was

necessary. After several variations the following procedure was adopted. The pieces are heated in a muffle furnace to 1250° C in 4 hours; after being held at this temperature for an hour they are quenched in cold water and allowed to remain in the water for a period of five minutes. When they are cold the transverse test is made, and those that withstand it are fired again the next day.

This transverse test is also made with the load-test lever. A heavy plank is laid across the top of the furnace and upon this is set an iron plate, holding two fixed prisms 6 inches apart. The test piece is set upon these and a third iron prism is placed directly under the bearing plate of the lever. The load is then applied by running out a weight on the lever arm, which has been calibrated for the pieces of different size. By trying this on a scale it was found that even if the weight does not move very smoothly the effective weight is never more than it should be as indicated by the position on the lever arm.

Summary of Results

We did not have quite the success that attended Schory's[1] efforts in discriminating between good and bad sagger mixes on the basis of absorption. We find some poor mixes well within the absorption field of long-lived ones.

In the cold state some mixes had moduli as low as 450 and others as high as 3000 lbs. per square inch. At 1200° C the weakest mix tested had a modulus of 70 lbs. and the strongest of 600 lbs. per square inch.

The figures given by Bleininger and Brown[2] show no uniform relation between hot and cold compressive strength of fire brick. For sagger mixes chosen at random there is likewise no regularity of relation between transverse-strength tests hot and cold, but we have made sagger mixes having very high strengths both hot and cold. The following figures demonstrate the last several points.

Nos. 12 and 67 have practically the same modulus cold yet 12 has only one-third the strength of the other when hot. No. 39

[1] Journal of the American Ceramic Society, **2**, 747 (1919).

[2] Transactions American Ceramic Society, **12**.

No.	Modulus of rupture	
	Cold	Hot
12	1130	153
67	1180	457
45	910	405
70	1290	558
39	2740	494

has an extremely high strength cold, more than 100 per cent higher than ordinarily found in very good mixes, and also has a very high strength hot.

Those pieces that have a high modulus of rupture at high temperatures are really stronger than the results show, for their longer loading periods introduce a time element that works against them. By a mathematical calculation it is possible to determine the instantaneous load that will cause rupture or the load necessary to effect a breaking at any given time shorter than the loading period for the individual test piece.

It is not possible to say definitely at this time that the moduli of rupture at 1300° C of sagger mixes are directly proportional to the life of saggers made from these mixes. However, comparisons which are now being made between the actual life of commercial saggers and the results of previous laboratory tests on the mixes used bear out this possibility. Furthermore, these same comparisons demonstrate that almost any sagger mix with a high modulus of rupture at 1300° C (say over 350 lbs. per sq. in. under the conditions described) can be made into a sagger that will give a comparatively long life in actual service.

The apparatus for this test can be made cheaply in any plant shop; and there are few places that do not have a small test furnace to which it may be attached. The equipment is very light and easy to set up and remove. Other methods, such as a small hydraulic jack, may be used for applying the loads. After trial pieces are made a high-temperature transverse-strength test can be run in five hours. This appears to give all the information desired about a sagger mix and to render it unnecessary to make any other tests.

It is essential in the initial firing of the trial pieces that they be subjected to the same burning treatment that will be given

the saggers and that the load test be conducted at a temperature at least as high as that at which the saggers will be used.

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Discussion

MR. M. C. BOOZE.—It is true that the best laboratory test for bat and sagger mixtures is one in which the hot strength is determined. The method of loading, however, is open to debate. I believe that, in the test outlined, the span was too short for the depth of test piece employed so that the influence of a poor bond clay would not be as prominent as desirable. A test which better meets the conditions of use is one in which the bar is uniformly loaded and the amount of deformation is determined. If possible the tests should be made in commercial kilns under working conditions.

MR. EDWARD C. STOVER.—This paper gives a number of practical tests and just how they are made, and should assist in locating some of the aggravating difficulties in this important sagger problem. A few suggestions might still be considered to advantage.

In avoiding troubles generally, the value of being able to reproduce at will the trouble in its various stages is frequently not appreciated. When this knowledge has been thoroughly acquired, how to obviate the particular difficulty in question is more easily and more certainly determined. In most all sagger mixtures is the item of grog (about $33^1/_3$ per cent or thereabout), and when the proper clay, or mixture, has been obtained, most people would say, "Oh, our grog is all right, we make this ourselves out of our own broken saggers," and it is hard to get them to look there for any of their losses in this line.

The testing appliances and methods described in this important and comprehensive paper should assist in locating and measuring some difficulties, and how to produce them, and thus how to stop producing them.

Here are a few points for consideration, that may suggest a few tests to make, keeping a careful record of the varying results for comparison, and how to duplicate when desired, and how not to duplicate when not desired.

In the first place, are you having kept a record of the life of your various size saggers, showing the average number of fires? And the various kinds of earlier losses? And the causes for said losses? Are you keeping all your ground grog in one place or bin? If so, how are you to know if it is too fine, or too coarse, or evenly distributed in each mixture of the proper degree of fineness? Or are you sub-dividing it into coarse (sending back to be reground that which has proven to be too coarse), medium and fine (rejecting that which has proven to be too fine for maximum strength), and carefully applying in each mixture the proper proportion of coarse, medium and fine grog, approximate sizes of each grade to be determined by these tests, as described?

To prove the value of this suggestion, have made a few test pieces as explained in the paper, using all coarse, a few all medium, and a few using all fine grog. Also a set of trials, using very coarse grog (such as should be reground) and a set with very fine grog (such as should be rejected), and note carefully the result of all these tests by the methods described in the paper, and you will probably be convinced that this is too important a matter to be totally ignored any longer. A microscope or a few microphotos will assist in seeing the results and in locating some difficulties.

With the transverse strength tests, and load tests, as described in the paper, and the uniformities, and thus the duplications, as desired, suggested in this discussion, you should be able not only to locate but to obviate some of your sagger difficulties.

MR. V. S. SCHORY.—The field of this investigation is one of great importance in the ceramic industries and this paper forms a valuable addition to the published data on the subject. In referring to my paper, J. AM. CERAM. SOC., **2**, 747 (1919), the authors apparently infer conclusions which are not justified by the data presented. No attempt was made to classify sagger mixtures on the basis of absorption except when the clay content of the sagger mixtures consisted of the same clays combined in different proportions, and then the terms "good" and "bad" can only be used relatively. Undoubtedly, good and poor sagger mixtures can have identical absorptions. However, if the clay content of sagger mixtures consists of one vitrifying clay and one open-burning clay combined in varying proportions there will

be found a short range of compositions which give better saggers than those containing a much less or a much greater proportion of vitrifying clay, and the degree of vitrification occurring in the best mixtures can be determined by an absorption test.

DR. ROBERT B. SOSMAN.—The authors make two assumptions which experience shows to be not always justified in the absence of direct measurements. They assume, first, that the temperature of the test piece is uniform to such a degree that the transverse tests are not affected by the lack of uniformity which always exists in any furnace; second, that the thermoelement, separated by the carbofrax slab and the protecting tube from the test piece, gives the true temperature of the test to the desired degree of accuracy. Both of these assumptions may be, and in this case very likely are, true; but I have never yet found a case where a preliminary exploration did not show much greater temperature gradients than had been supposed to exist. High thermal conductivity, in particular, does not insure uniformity where a large amount of heat is flowing. I believe that the actual distribution should always be determined by a special set of measurements, which need not be elaborate nor take very long to make.

MR. S. J. MCDOWELL.—Since reducing atmosphere has a marked effect on fire-clay refractories, I should like to ask if any tests in this paper were carried on under reducing conditions and if so what variation in strength was found?

AUTHOR'S CLOSURE.—In replying to Mr. Booze we may say that saggers that soften in use in kilns are quite evidently of inferior quality and are not suitable for commercial use, even though they can be made from cheap clays. There was no endeavor made to measure the softening; but incidentally this fact is noted in the high temperature load test. The important thing about good sagger mixes, however, is not the softening, but is the lowering of the mechanical strength at the increased temperatures. One set of results can be used to bring out an important point.

	(1)	(2)	(3)
Per cent of vitrifying clay	40	35	30
Per cent of open burning clay	10	15	20
Per cent of grog	50	50	50
Modules of rupture at 1300° C, lbs. sq. in.	206	222	113

All of these three mixes were of sufficiently good appearance to promise saggers of about the same quality; mix No. 1 was not too dense and mix No. 3 was not noticeably porous. We see no way in which an arbitrary softening and deformation test is suggested by Mr. Booze would distinguish between these mixes. Over a longer span or under their own or some arbitrary weight less than enough to cause rupture, mix No. 3 would remain unbended while the others would show differing degrees of deformation, and hence No. 3 would be chosen as the superior mix.

One reply to this probably will be that any load that will cause deformation of mixes 1 and 2 will cause rupture of 3. In many instances this might be so, but there undoubtedly are cases where a given load would cause a bending of one piece and would be just sufficiently short of enough to effect rupture of another, and because the second piece did not bend it would be mistaken for a good mix.

A high temperature transverse strength test would give us the ultimate strength of both mixes and at the same time would tell whether or not any deformation occurred, and thus indicate by what variations in composition the mix could be improved.

It is easy to comprehend that if two sagger mixes have the same rate of deterioration of strength in use, the one with the higher initial strength will have the longer life, and the probability is, also, that the stronger one will deteriorate less rapidly than the other.

Most refractory materials have a much lower mechanical strength when hot than when cold, and in very many instances the major cause is not the softening brought about by the vitrifying clay. It is simply that the physical properties are not the same at all temperatures. A high temperature transverse-strength, however, distinguishes between failure due to softening and those due to other weakness, for in the first case the test piece bends before rupture and in the second the piece fails without deformation.

Attempting to conduct the test in commercial kilns, as Mr. Booze suggests, would greatly aggravate the lack of uniformity that Mr. Sosman points out and would render impossible the control of conditions that allows of a fair comparison of results.

In replying to Mr. Stover we may say that, as stated in the contents of the paper, some work was done with reference to the sizing of grog in sagger mixtures, which is known to be of very much importance. In this connection, Mr. Stover might be referred to the work of Mr. F. A. Kirkpatrick, *Transactions American Ceramic Society*, **19**, p. 268.

No aim was made in the paper under discussion to tell how to make sagger mixes or what to put into them. As the title clearly brings out all that was attempted was to set forth a quick and effective method for testing such mixes and determining their probable relative values.

Mr. Schory's method is a refinement of the one generally employed. Usually a burned sagger is examined only and if the mix appears to be too dense or too porous, the proportions of the vitrifying and the open burning clays are altered until the desired vitrification is obtained.

In answer to Dr. Sosman, we may say that one preliminary holding period of forty-five minutes and the continued maintenance of the furnace at the same temperature all through the loading period were assumed to make possible some uniformity of temperature. In a small space in a furnace that is being held at a constant temperature it is not unreasonable to expect greater uniformity than if the temperature is being raised or lowered rapidly.

The test piece, moreover, was surrounded by a carbofrax muffle set parallel to and equidistant from its corresponding sides. This entirely prevented the flame from striking the test piece. No such precaution is taken in the standard high temperature compression test of fire brick, but it undoubtedly should be to obviate spot heating.

It was not assumed that the results would not be affected by the lack of uniformity of the temperature of the test pieces; all of the refinements to promote uniformity that it was reasonable to make were made, and as far as there was possibility of control, conditions of any individual test duplicated those of any other. Little more than this can be done in such work.

In answer to the question of Mr. McDowell, we will say that oxidizing conditions were maintained throughout all of the tests

thus far completed. It is unlikely that reducing conditions would effect marked changes in the strengths of mixes containing relatively small amounts of iron or other compounds that are easily altered by reducing gases.

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

BEHAVIOR OF FIRE BRICK IN MALLEABLE FURNACE BUNGS[1,2]

By H. G. Schurecht

The properties necessary for a good malleable furnace brick are evidently not well understood as brick which pass the customary laboratory test, such as the load and softening point test, often fail when used in malleable furnace bungs.

A more thorough study of the relations between the properties of brick and their ability to stand up in bungs has been undertaken by the Bureau of Mines in order to determine the qualifications a brick must possess in order to give long service.

Complete seven-foot arches containing 40 bung brick were tested, as shown in Fig. 1. The number of heats which these

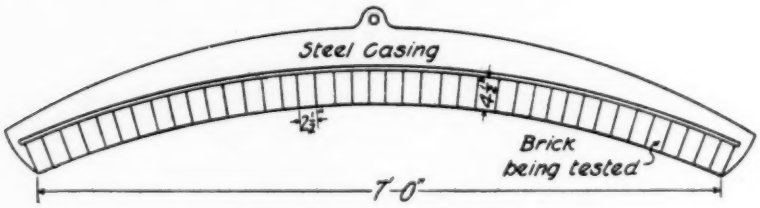


Fig. 1.—Bung of brick as tested.

arches would stand in practice (from 3 to 23 heats, according to the brick) was used as a means of comparing their serviceability. The brick were placed in a definite position over the fire box, where they received the severest heat. The tests were made on a forty-ton malleable furnace operated by the Ohio Malleable Iron Co., Columbus, Ohio. In the laboratory tests the bulk specific gravity, porosity, per cent deformation under load, softening point and chemical analyses were determined, these tests being made in the customary manner. The results are tabulated in table 1.

[1] Received Feb. 27, 1920. Read at the Philadelphia meeting.

[2] By permission of the Director, U. S. Bureau of Mines.

TABLE 1—TESTS ON FIRE BRICK FOR MALLEABLE FURNACE BUNGS

No.	Heats	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O Na_2O	Bulk spec. grav.	% porosity	% deform. with load of 25 lbs. per sq. in. at 1350° C.	Fusion cone	Method of making
1.....	18	52.93	42.69	1.98	0.33	0.38	1.55	2.04	15.50	12.2	32	Soft mud
1.....	18	52.20	43.42	2.18	.40	.40	1.47	2.0	15.60	15.2	30	Soft mud
3.....	18	...	...	..	..	..	..	1.98	15.60	6.6	$32\frac{1}{2}$	Soft mud
4.....	14	52.60	43.22	2.00	.40	.30	1.68	1.89	19.4	4.6	32	Soft mud
5.....	12	52.60	43 71	1.98	.41	.30	1.68	1.94	15.90	12.8	32	Soft mud
6.....	3	66.22	29.83	1.12	.27	.29	1.24	2.03	13.4	11.8	$30\frac{1}{2}$	Dry press

Three brick stood up 18 heats. Nos. 1 and 2 show a high alumina content, 42.69 and 43.42 per cent, respectively; also a high bulk specific gravity and low porosity. The chemical analysis of No. 3 has to the present time not been determined, but it also shows a high bulk specific gravity and low porosity. Although these brick, stand up best in practice the resistance of Nos. 1 and 2 to load at high temperatures is not very good and the fusion or deformation test would class No. 2 as a second grade refractory. In Fig. 1 it is seen that the brick are not subjected to heavy load and that one end of the brick is kept cool so the load test and softening point test are not important. Brick No. 4 shows load and fusion tests superior to brick No. 2, yet it does not stand up in practice as well. Its bulk specific gravity is, however, smaller, being 1.89 as compared to 2.01 for No. 2, and this may account for its poorer behavior in practice. The porosity is also comparatively higher, being 19.4 per cent as compared to 15.6 per cent for No. 2 brick. Brick No. 5 also has comparatively a low specific gravity and high porosity.

Brick No. 6 tested poorest in practice. It was made dry press and fired to cone 14, being different in this respect from the other brick which were made soft mud and fired to a lower temperature. It, however, shows a high specific gravity and a low porosity comparing favorably with the best soft mud brick in these respects. Its chemical analysis, is, however, considerably different from those of the other brick. It contains only 28.83 per cent alumina while the other brick contained 42.69–43.71 per cent, which may account for its poor behavior in furnaces. A highly siliceous brick is more readily attacked by basic slags and gases and is also less resistant to spalling than the aluminous brick.

It appears, therefore, that highly aluminous brick with high bulk specific gravity and low porosity are desirable for malleable furnace bungs. These tests are, however, not conclusive as only one test has been made on the brick in bungs, with the exception of No. 6, which has been given three tests. Two or three more checks are now being made on the other brick. The data herein given are therefore, subject to revision on completion of the tests.

In conclusion, the author wishes to acknowledge his indebtedness to Mr. J. M. Kittle, of the Ohio Malleable Iron Co., and Mr. J. M. McDowell, of the Harbison-Walker Co., for their coöperation in this work.

CERAMIC LABORATORIES, U. S. BUREAU OF MINES
MINING EXPERIMENT STATION, COLUMBUS, OHIO

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

RELATIVE ACTION OF ACIDS ON ENAMELS. IV[1]

Introduction

There were published in Volume II of the JOURNAL OF THE AMERICAN CERAMIC SOCIETY[2] results of the preliminary work of the Sub-Committee on Enamels of the Standards Committee. This covered various considerations as to the choice of the proper acid to form the basis of a standard acid test for enamels. It was brought out that an acid procurable in the solid form would have advantages over acids existing in the form of a liquid, assuming such an acid could be found that would be uniform in strength as purchased on the market. Citric and tartaric acids were studied as to their stability and uniformity with the conclusion that either of these from these points of view should make the basis of a satisfactory standard solution.

The additional investigations being reported herewith take the matter up at this point and cover all of the work which has been done up to the present time.

No definite conclusion has been reached and the available data are being presented at this time merely as a matter of general interest in connection with the subject of the action of acids on enamel.

Choice of Acid

The first problem was a choice between citric and tartaric acids. It seemed advisable to obtain the opinion of various food chemists as to the relative merits of these acids for the purpose in mind, and it was the consensus of opinion of those consulted, including such parties as the chemical staff of the H. J. Heinz Company, that citric acid offers a fairer means of testing than does tartaric. Hence it was decided to confine our efforts to the application of citric acid until some conclusion might be reached.

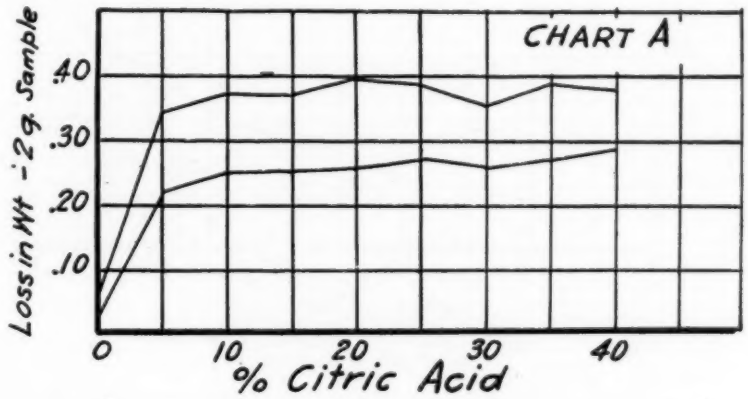
It was desired to make further study of the action of citric acid

[1] Received Feb. 27, 1920.

[2] "Relative Action of Acids on Enamel, III." *Jour. Am. Ceram. Soc.*, **2**, 32.

on enamels, both as to variation in concentration of acid at constant temperatures and variations in temperature at constant strength.

The first investigation was carried on by means of the frit test previously described[1] and using two different fruits with results shown on chart A. From these curves it was noted that there



is a reasonable uniformity of action around 15 per cent acid, small variations of concentration in either direction, making but slight effect in the total activity. Although there are possible irregularities in the curve at higher concentrations, the object in view did not warrant further investigation along this line. It was decided to take 15 per cent as the approximate strength of the desired solution.

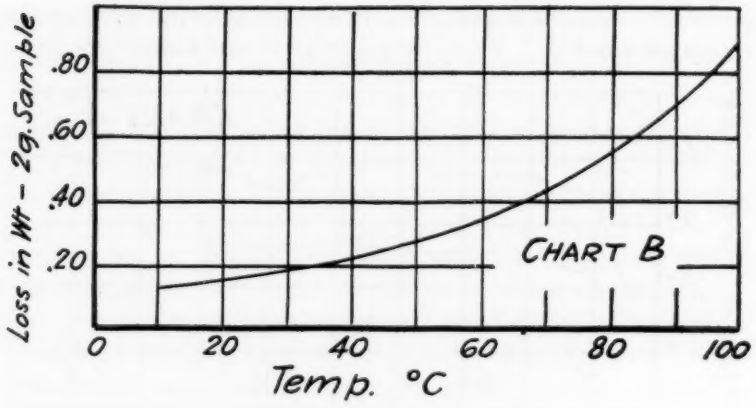
To determine the variations in action due to temperature changes a series of frit tests on a standard frit was made using 15 per cent citric acid by placing the frit and acid in a flask under a reflux condenser and running the test for one hour at each of several temperatures.

The results of these tests are plotted on chart B, which shows the effect of varying temperatures on the activity of citric acid.

From this curve it can be assumed that variations in temperature that might occur in the laboratory at different seasons of the

[1] "Relative Action of Acids on Enamels," *Trans. Am. Ceram. Soc.*, 17, 138.

year ranging from 15 to 35° C would materially effect the results of the standard test, a fact pointing to the necessity of temperature control.



Standard Solution

In making specifications for the strength of a possible solution it seemed feasible to adopt such units as would make use of the English system of weights and measures, eliminating fractional parts. Six ounces of citric acid dissolved in one quart of water makes a solution with the theoretical strength of 15.73 per cent, which was adopted as a standard.

To determine the possible uniformity of solutions made up by different people, four parties were requested to purchase from local drug stores samples of citric acid for analysis in the dry form and also to make up samples of solution in accordance with the above specifications.

Analyses of the various samples thus received are shown in table 1:

TABLE 1

Source	Dry sample % citric acid	Ash	Solution strength
Sw	100.14	0.02	16.06
Ft	100.08	.08	15.19
Dn	100.14	.03	15.75
Ss	100.35	.03	15.74
Average	100.18	.04	15.68

It will be noted that the average solution strength was 15.68 per cent compared with the theoretical 15.73 per cent, and that none of the samples varied in a sufficient degree to make an appreciable difference in the action on enamel as indicated on curve A. It is also observed that the amount of ash in the various samples ran very low, only one exceeding the specifications of the U. S. P., 0.05 per cent.

The conclusion from the above tests was that the citric acid obtained from drug stores was sufficiently uniform to make possible the making of a standard solution according to the specifications, within reasonable limits of accuracy. The only possible point was the effect of the ash on gravimetric phases of the test, a matter which will be covered later.

Application to Commercial Ware

Having thus decided upon a tentative standard solution an effort was made to determine the manner in which this solution would effect commercial ware. Several types of sample dishes were used in these tests. In series A three dishes were tested designated as "M," "E-O," and "E-1." "M" was a small white pudding pan furnished by a producer of cooking ware; "E-O" was coated with a relatively high acid resisting enamel used in the manufacture of heavy canning equipment; while "E-1" was coated with a less acid-resisting enamel used in the manufacture of large dairy equipment.

These three dishes were each tested with the standard solution for 24 hours at temperatures ranging from 12 to 20° C, at the end of which times dishes "M" and "E-1" showed a very marked etching and "E-O" no etching.

To determine the possibility of getting consistent gravimetric values from the solution which had been used in such a test, the liquid from the white dish, together with the rinse water used after rubbing the tested area with a rubber tipped stirring rod, was diluted to 500 cc. and two 100 cc. samples were taken, each after a thorough shaking of the flask, and evaporated to dryness and ignited in weighed platinum dishes. The gains in weight were 0.0154 and 0.0141 gram, a variation of 9.2 per cent based on the smaller figure.

In view of the fact that the first piece of commercial cooking ware tested showed a definite etching under the conditions of the test, it seemed desirable to ascertain whether this particular ware was as resistant as the average cooking ware on the market. Four samples of commercial ware were obtained from local stores and tested in series B. "I" was a white inside and blue mottled outside ware of rather inferior grade, poor in gloss; "SS" was a similar ware of a somewhat better gloss; "CE" was a white pudding pan of good grade; "SE" was a very similar piece of ware. These four dishes were tested under approximately the same conditions as existed in series A with the following results: "I" was badly etched almost chalked;[1] "SS" was badly etched, but not as deeply as "I"; "CE" was slightly etched and "SE" was slightly etched.

As a further test of the possible gravimetric application, series C was run, using dishes "M-3," "M-4," "M-5," all of the same size and from the same batch of first-class ware. After standing 24 hours the dishes showed a uniform etching, and the solutions from each were diluted to 500 cc. as above and ignitions made on the residue from 100 cc. samples. A similar test was made on a blank, using the same amount of the original test solution as had been introduced into each of the dishes. The gravimetric values are shown in table 2, indicating that a reasonable check is possible on three dishes tested under parallel conditions and that the figure due to the ash in the original acid is relatively insignificant. It might be observed that the actual values are objectionably small, suggesting the advisability of having perhaps a 200 cc. sample rather than a 100 cc.

TABLE 2

Sample	Residue Gr.
M-3	0.0088
M-4	.0084
M-5	.0079
Blank	.0006

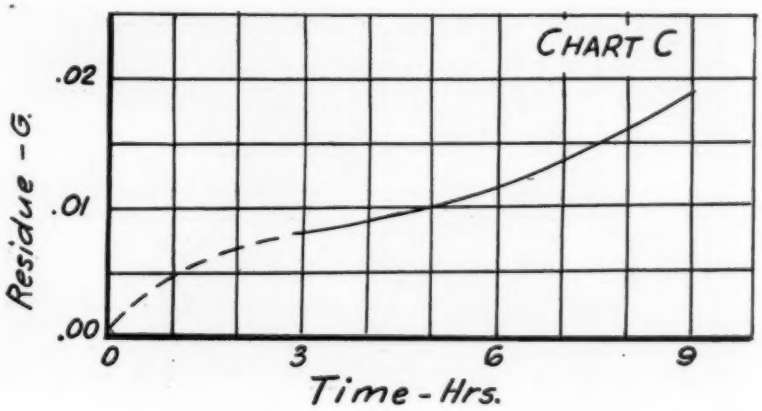
Possible Modifications

Realizing that at least dish "M" in series A and dishes "CE" and "SE" in series B were of first-class quality, it was decided

[1] *Trans. Am. Ceram. Soc.*, **19**, 150.

to consider modifications of this general method of testing, either as to time, temperature or strength of acid, so as to be able to have the better grade wares show no etching.

The first variation attempted was shortening the time in series D, dishes "M-6," "M-7" and "M-8" of uniform shape and quality were each filled with 200 cc. of standard solution. The first was emptied after three hours, the second after six hours, and the third after nine hours. Definite etching was noted in the first with increased etching in the other two. One hundred cc. samples were taken from 500 cc. dilutions giving results indicated in chart C. It will be observed that the values are higher than



would have been expected from tests on the same grade of ware in series C. This was partially due, at least, to the fact that series D was run at a much higher laboratory temperature than series C.

The next modification to be investigated was that of diluting the solution. Series E was run, using dishes "M-9," "M-10," "M-11," "M-12," "M-13," and "M-14," all of the same shape and grade, and the solutions used were $^1/_2$, $^1/_4$, $^1/_8$, $^1/_{16}$, $^1/_{32}$ and $^1/_{64}$ of the strength of the standard solution, which expressed in percentages, are as follows: 7.88 per cent, 3.94 per cent, 1.97 per cent, 0.95 per cent, 0.49 per cent and 0.25 per cent. As would be expected, the amount of etching dropped off readily as the acid strength had now fallen below the break in the curve

on chart A. Faint etchings could be noted on the dishes which contained the more concentrated acid, but it was very difficult to determine which, if any, dishes showed no etching.

Detection of Etching

This brought up the question of determining when a dish was etched and when it was not etched, a point which it seemed necessary to settle before further experiments with the method of testing could be intelligently interpreted.

Two general schemes were tried on series E. Some finely ground charcoal was rubbed on the enamel on one side of each

PLATE 1.—Showing the effect of malachite green solution on enameled dishes etched with acid.

dish by means of the finger. This produced in all cases a definite discoloration of the etched portion but no discoloration of the enamel above the liquor line. The relative intensity of this discoloration was not proportional and could be varied by the manner in which the material was rubbed on. This suggested the necessity of some other means of producing a color effect, and a three gram per liter solution of malachite green was used in a preliminary way on the same dishes from series E. A small amount of this solution was placed in each of the dishes and allowed to stand five minutes and the dishes rinsed out. The resulting discoloration of the etched portion seemed to be reasonably

proportional to the strength of the acids which had been in the dishes, and the unetched portion showed no discoloration.

As a more definite test of the same type series F was run on dishes "Fo," "Fa," "Fb." In dish "Fa" 200 cc. of 5 per cent citric acid was placed and in dish "Fb" 200 cc. of 10 per cent citric acid; and the two dishes were allowed to stand for 1½ hours after which these two dishes were emptied and thoroughly washed with hot water, as was also dish "Fo," which was being used as a control and had received no acid treatment. After thoroughly drying the dishes 100 cc. of the malachite green solution was placed in each and allowed to stand for several hours. The solution was removed and the dishes rinsed with hot water and dried, after which "Fo" had no discoloration, "Fa" a marked discoloration and "Fb" a very deep discoloration. These are shown in plate 1.

ELYRIA ENAMELED PRODUCTS CO.
ELYRIA, OHIO

Discussion

MR. J. B. SHAW.—This paper, while only a report of progress, represents a very large amount of carefully executed experimental work and discloses very material progress in arriving at the desired result. The author has obviously kept in mind and given due consideration to the fact that any test adopted must not be prejudicial to the best interests of the manufacturers of enameled iron ware. At the same time it is quite obvious that a test to be of any value must have within it the possibility of classifying enameled ware as regards its ability to resist corrosion by solvents. This is essential not only from the standpoint of the public but also of the manufacturer. There is no hope for any material improvement in this class of ware until the manufacturer adopts the practice of studying the quality of his ware and taking steps to improve it wherein it is weak. In order for him to be able to distinguish a good quality from a poor one, some such test as is here recommended is necessary. It would seem that the manufacturers should take up this work and profit by the results demonstrated in this paper.

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the editor.*

MAGNESITE REFRACTORIES

J. Spotts McDowell and Raymond M. Howe

Errata

Page 187, line 5 from top, change "Loeben" to Leoben."

Page 194, line 6 below table, change "$7MgO.CO_3$" to "$7MgO.CO_2$."

Page 195, line 12, change "crystalline magnesia" to "crystalline magnesite."

Page 196, lines 4 and 5 from top, change "Semmering, (Eichberg) Veitsch, Biretenau, Trieben, Redenthein (Minstatt) and Dientin (Salzburg)" to "Semmering (Eichberg), Veitsch, Breitenau, Trieben, Radenthein (Millstatt), and Dienten (Salzburg)."

Page 201, line 4 from top, insert the words "in the state" after the word "annually."

Page 216, line 9 from top, omit the words "and shown graphically in sketch 2."

Page 219, line 3 from top, change "effected" to "affected."

Page 224, Figure 2. A straight line should be plotted from 445° C to 830° C, showing a constant conductivity of 0.0135.

Page 225, line 12 from top, change "$\frac{K°}{1000°}$" = to "Between the limits of 0° and 1000°, K = ".

Page 225, line 9, change "between 0° and 1000° C of 0.100" to "between 0° and 1000° C of .0100."

Page 225, line 12, change "$\frac{K°}{1000°} = 0.0124$" to "$K^{0°}_{1000°} =$ 0.0124, etc."

Page 225, line 20 from top, change "$0.0_4 379^t$" to "$0.0_4 379\ t$."

Page 229, line 6 under Part VI, insert the world "the" between the words "higher" and "temperature."

Page 231, line 13 from top, change "refractions" to "refraction."

Page 235, table of Analysis, change "MgFe" to "Mg : Fe."

NOTE ON PORCELAIN GLASS POT MIXTURES[1,2]

By D. H. Fuller

The use of porcelain pot mixtures in this laboratory made it desirable to know the physical properties of these materials, with reference to their drying shrinkage and porosity upon firing to a series of temperatures, mechanical strength in the fired state, resistance to load conditions and their softening point. Such data are important for checking up the properties of the body produced, as a matter of record and for the determination of the proper pre-firing or arching temperature.

It was also thought desirable to study a number of such compositions varying principally with reference to the sizing of the grog, for which whiteware bisque was invariably employed and with reference to the presence or absence of feldspar.

The compositions of the body mixtures are given in table 1. It will be observed that the amount of grog dust was kept down to a

Table 1—Body Compositions

	Body No. 1 %	2 %	3 %	4 %	5 %	6 %	7 %
Feldspar	6.50	0.00	0.00	6.50	6.50	6.00	6.00
Ky. Ball No. 4	11.00	11.00	14.25	11.00	11.00	10.00	10.00
Tenn. Ball No. 5	11.00	11.00	14.25	11.00	11.00	10.00	10.00
N. C. kaolin	11.75	18.25	11.75	11.75	11.75	12.50	12.50
Del. kaolin	5.87	5.87	5.87	5.87	5.87	4.50	4.50
Ga. kaolin	5.87	5.87	5.87	5.87	5.87	4.50	4.50
Grog 10–20 mesh	16.80	14.40	14.40	.00	38.40	18.40	15.80
Grog 20–40 mesh	19.20	19.20	19.20	43.20	.00	23.60	21.00
Grog 40–80 mesh	9.60	12.00	12.00	.00	4.80	10.50	8.90
Grog 80 dust	2.40	2.40	2.40	4.80	4.80		6.80

low figure, a condition made necessary by the quick cooling of the glass pots in use. The results of the physical tests are compiled in table II. A description of the tests is unnecessary since they have been discussed amply in the literature. It might be

[1] Received Feb. 27, 1920.

[2] By permission of the Director, Bureau of Standards.

stated, however, that the load test was carried to a maximum temperature of 1350° C and the pressure maintained was 50 pounds per square inch. The specimens for this test were fired to cone 15. The transverse strength of the fired bodies was upon bars previously burned to cone 15.

TABLE 2—RESULTS OF PHYSICAL TESTS

No.	Water content in plastic state Per cent	Drying shrinkage in terms of dry vol. Per cent	Modulus of rupture in dried state, lbs. per sq. in.	Modulus of rupture fired to cone 15 lbs. per sq. in.	Contraction in load test, per cent of original length	Fusion point Cones
1..	19.43	5.39	298	1976	1.4	31
2..	21.82	7.54	269	2095	0.24	31
3..	21.82	7.68	260	1838	0.12	32
4..	21.41	7.08	263	2244	0.29	31
5..	20.23	6.67	155	1572	0.02	32
6..	19.66	6.31	213	1998	0.06	31
7..	19.83	7.22	250	2299	0.12	31

Discussion of Results.—It will be noted that the water content and the drying shrinkage show no marked differences, and that the strength in the dry state is greatest when the content of coarse grog, 10–20 mesh, is relatively low and the material sized between the 20 and 80-mesh sieve higher. Undoubtedly the presence of larger amounts of finer dust would have resulted in greater strength in the dried state. Practically the same statement holds for the transverse strength of the bodies fired to cone 15. From the load tests results it is apparent that these bodies resist pressure conditions under furnace conditions very satisfactorily indeed, due principally to the high silica content of the whiteware bisque grog. The relatively large contraction of body No. 1 cannot be explained from the composition but is perhaps due to a lower degree of burning. The fusion points of the porcelain materials are practically of the same magnitude, cones 31–32.

Firing Behavior.—Briquettes of the seven bodies were made and fired to 8 temperatures, from cones 1 to 15, inclusive, maintaining as closely as possible a steady temperature increase of 20° C per hour. The usual determinations of the volume shrinkage, expressed in terms of the dry volume and of the porosity were made.

The results of this work are compiled in table 3. From the values obtained it is noted that the general behavior of these bodies in firing is practically the same. The most rapid rate of vitrification takes place between cones 11 and 13. The densest body at the latter temperature is No. 7, though No. 1 is very close

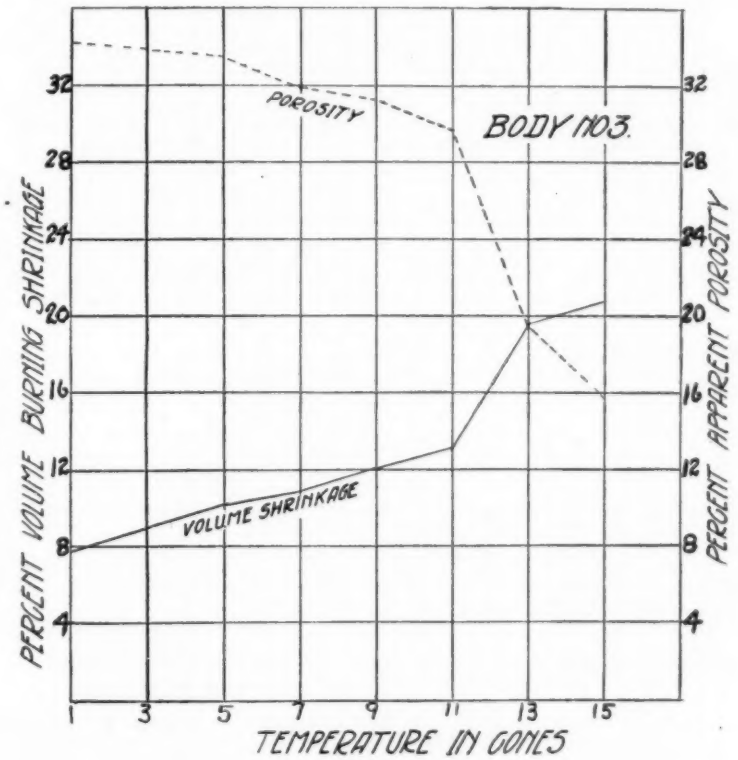


FIG. 1.

to it. The most open structure is shown by No. 2. At cone 15 the minimum porosity is again shown by No. 7, followed closely by Nos. 1 and 6. That lower porosities have not been reached is evidently due to the comparatively coarse grog employed, a condition made necessary by the treatment of the pots which were exposed to an air blast, immediately after the finish of the stirring. Pots practically completely vitrified, obtained through

the use of fine bisque were apt to crack in the cooling. It is evident, however, that the pre-firing of pots of this type must be carried at least to the temperature corresponding to cone 15. The higher porosities of bodies Nos. 2 and 3 are evidently due to the absence of feldspar and in No. 5 to the use of a coarse grog mixture.

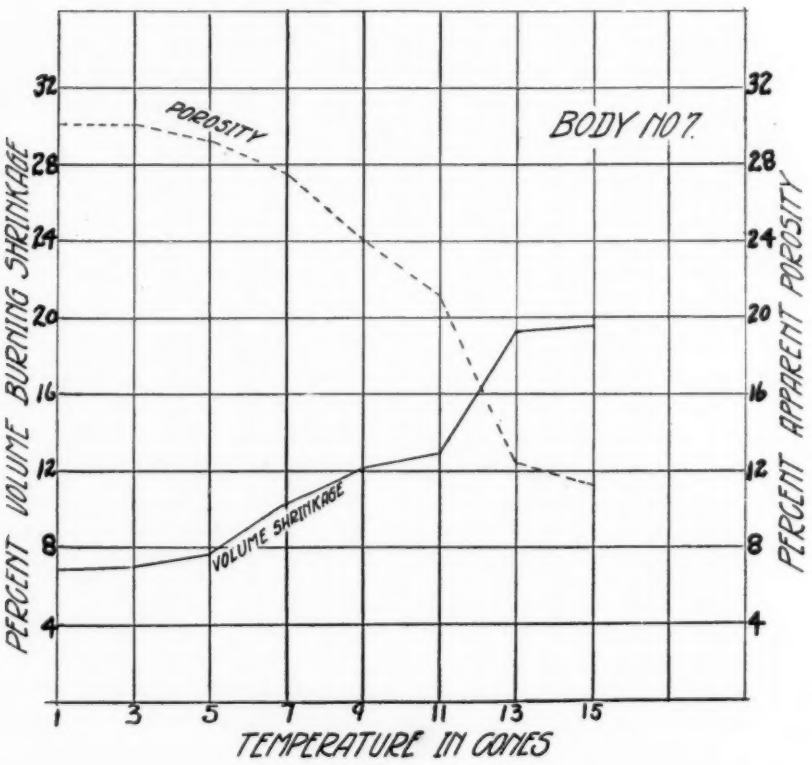


FIG. 2.

The volume shrinkage of the different bodies at 1342° C vary from 15.57 to 22.32%, the lowest value being again that of the coarsest grog combination. The typical firing behavior of these porcelain pot compositions is shown graphically in the diagrams of Figs. 1 and 2.

It would seem from the results obtained that an important factor in regulating the structure of such bodies is to be looked for in the sizing of the bisque grog. Coarser calcine will retard vitrification and result in a more open texture white fine material

TABLE 3—RESULTS OF FIRING TESTS

	Cone 1, 1090° C		Cone 3, 1100° C		Cone 5, 1164° C		Cone 7, 1180° C	
No.	Vol. shrink. Per cent	Porosity Per cent	Vol. shrink. Per cent	Porosity Per cent	Vol. shrink. Per cent	Porosity Per cent	Vol. shrink. Per cent	Porosity Per cent
1.....	7.24	31.18	7.40	30.47	8.69	30.13	10.01	27.78
2.....	7.48	34.58	7.42	33.22	8.02	33.15	8.60	32.33
3.....	7.78	34.23	8.90	33.90	10.17	33.48	10.80	31.97
4.....	7.88	33.17	8.40	32.78	9.35	31.58	11.22	30.52
5.....	7.03	31.03	8.07	30.90	8.68	30.76	10.37	29.55
6.....	5.65	31.77	7.28	31.47	8.92	30.60	10.72	28.67
7.....	6.93	30.17	7.05	30.10	7.65	29.30	10.30	27.52
	Cone 9, 1203° C		Cone 11, 1244° C		Cone 13, 1312° C		Cone 15, 1343° C	
1.....	12.18	25.92	14.13	23.62	19.53	13.78	20.17	11.83
2.....	10.13	31.33	11.95	29.47	18.45	20.50	20.75	16.07
3.....	12.05	31.25	13.05	29.68	19.62	19.57	20.73	15.73
4.....	13.82	27.73	15.57	26.47	21.07	16.72	22.32	12.83
5.....	10.70	26.68	11.83	24.58	15.22	16.85	15.57	15.18
6.....	12.25	26.65	14.70	24.00	20.43	15.27	20.62	11.47
7.....	12.18	24.07	12.95	23.08	19.32	12.42	19.55	11.33

will promote the vitrifying process and yield a denser body. This factor appears to be as effective as the addition or elimination of feldspar. It is evident that in this case we are dealing with a grog tending itself to vitrify at higher temperatures and which develops this action in proportion to its fineness.

The second important factor in governing the state of vitrification is the addition of feldspar which is more effective the finer the bisque grog, and *vice versa*. For obvious reasons there is a definite limit of feldspar content which can not be exceeded without impairing the rigidity of the pots at the higher melting temperatures, around 1450° C, and this seems to be at about 8 per cent. For the purpose for which these pot bodies have been employed the compositions corresponding to Nos. 1, 6 and 7 would appear to be most satisfactory, the last one having perhaps the most desirable structure.

Discussion

MR. A. F. GORTON.—Although the paper deals with pot compositions of the porcleain type and of coarser texture than ordinary commercial pot bodies, I believe that the results obtained should be of great value to all pot manufacturers. Mr. Fuller has selected those physical properties for his tests which are of greatest importance in estimating the value of pot materials, and the results, on the whole, conform very closely to what might be expected from consideration of the composition of the seven bodies.

I would call attention particularly to the load test and to the effect of the sizing of the grog. Those who have used the warpage test as a means of judging the tendency of pot walls to bulge at high temperatures will, I think, agree that the test is of dubious value, except in a purely comparative way, because it is difficult to standardize testing conditions, and the distortion itself does not correspond exactly to actual conditions. If one considers the hydrostatic pressure of the glass inside the pot, and the pressure due to the weight of the walls and crown above the level in question (which is, say, six inches above the bottom, inside) then it appears that the former quantity is numerically about 1.5 to 2 pounds per square inch, and the latter is from 3 to 5 pounds per square inch, depending on the thickness of wall at that level. Consequently the greater distorting force is that due to the supported weight of clay. Hence the load test may logically be employed, and it seems that it would be better to perform the load test at a temperature higher than 1350° C, also under a smaller load than 40 pounds per square inch.

Mr. Fuller has well brought out the effect of the size of grog upon the modulus of rupture, porosity, and so forth, and I wish that this matter were more deeply appreciated by pot manufacturers, as I believe there is more to be gained by regulating the proportions of fine and coarse grog and the elimination of dust, than by an anxious search for some clay or blend of clays which shall approximate to the old German clay.

NOTICE.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

CERAMIC ABSTRACTS

General

Clays and shales of Minnesota. F. F. Grout and E. K. Soper. U. S. G. S., *Bull.* **678,** (1919).—A general discussion of clay, its origin, geologic types of deposits, the mineralogic, chemical and physical properties of clay its classification and adaptability, the technology of clay and uses of clay products serves as an introduction to the more detailed consideration of Minnesota's clay and shale resources. The geologic history of the state is outlined and the clay deposits of the various formations stated together with the adaptability of the materials. Refractory clays occur in the southwestern part of Minnesota, and are derived in part from the Archean and in part from the Cretaceous formations. Semi-refractory materials, the only source of which is the Cretaceous, are not fully explored. Prospecting and drilling should be employed in searching for these valuable deposits. The Decorah and Cretaceous shales and the Pleistocene red drift constitute the chief sources of non-refractory vitrifying clays. Among such materials may be mentioned the Huronian slates which when mixed with clay from the drift will make a fancy brick of excellent grade. The gray drift is unsuited for brick manufacture until the pebbles have been removed. With such treatment it may make not only brick but excellent drain tile. Non-refractory clays that soften rapidly as their fusion temperature is approached and are suitable only for common brick, draintile, fireproofing or slip glazing, are of widespread occurrence and include nearly all gray drift clays and gray laminated clay silts. The lakes and swamps throughout Minnesota, especially those which may be easily drained should receive careful consideration since clays occupying them may be of value. Greater exploration of clays and shales by drilling and stratigraphic methods of prospecting is especially recommended. The clays and shales of the state are considered by counties and the deposits described in detail. Numerous photographs, sections, analyses and tests are included in the report. E. D. Elston.

Summary report of the Mines Branch of the Dept. of Mines for 1918. Ottawa (1920).—Investigations of graphite and silica are summed up and a brief report of the Ceramic Division is included in which are given the results of tests made on materials from various localities in British Columia, Eastern Ontario and Northern Ontario. Of especial interest is a brief discussion of some Canadian Bentonite deposits, and a series of pottery and fire clays from Northern Ontario, which resemble the clays described by Ries and Keele from the Musquodoboit Valley of Nova Scotia. E. D. Elston.

Report on the barytes deposits of Georgia. J. P. D. HULL. Geol. Surv. of Ga., *Bull.* **36** (1920).—Barite, the deposits, geographic distribution and uses of barytes, together with production, imports and consumption of the material are briefly treated in the introduction.

In Georgia, the deposits occur in the northwestern part of the state, mainly in the Appalachian Valley, the principal district being near Cartersville, Bartow County. Some deposits, however, occur in the Piedmont Plateau. Six types of deposits, according to mode of occurrence, are stated: (1) vein, (2) replacement, (3) breccia, (4) residual, (5) colluvial, (6) alluvial. Only the residual and colluvial types are of commercial importance although some of the vein deposits have been worked on a small scale. Two principal types of ore occur: (1) crystalline, either coarse or fine in texture, generally translucent in thin fragments and generally slightly bluish white in color, (2) granular, opaque, dull white and finely granular. Briefly, the deposits have originated apparently in the following manner: circulating meteoric and thermal waters dissolved barium from the feldspars and micas of crystalline rocks and carried it through faults and fractures to limestone formations where favorable conditions brought about deposition of barium sulphate, barytes. The report includes, maps, photographs, analyses and sections.

E. D. ELSTON.

Used plaster molds. ANON. *Tonind.-Ztg.*, **44**, 397 (1920).—Old plaster molds are crushed and molded into brick. The voids are filled with fresh plaster which upon setting acts as a bond in forming the brick.

H. G. SCHURECHT.

Making the kiln crown waterproof. ANON. *Brit. Clayworker*, **29**, 16 (1920).—One method consists in covering the crown with a layer of ashes, clay and brick bats and then laying on a cement-lime motar. A mixture of cement with six times its volume of fine sand may then be applied in the form of four $^1/_4$ in. layers. The first three layers will tend to crack but the fourth will show very little carcking. For very thick crowns painting the crown with pitch each season will give satisfactory results. Where expense is not important one of the best methods is to cover the crown with a mixture of kieselguhr and clay dust and on this to lay specially made hollow blocks. Any water entering the joints between the blocks is stopped by the clay and kieselguhr and a particularly dry crown is formed. A somewhat cheaper but inferior material which may be used as a substitute for keiselguhr is a layer of ashes covered with 1 in. of clay dust. H. G. SCHURECHT.

Thermal expansion of insulating materials. W. H. SOUDER AND PETER HIDNERT. Bur. Standards, *Sci. Paper* **352** (1919).—In the furnaces used for tests, the specimen was supported horizontally and a 2 mm. platinum wire hung over each end. Each wire, hanging through a hollow tube below the end of the specimen and extending downward through and below the furnace,

had at its lower end a vane (or weight) immersed in oil in order to dampen the vibrations. Heating was effected by electric resistance coils (outside, inside, and end coils). The length changes were determined with a comparator consisting of two microscopes rigidly clamped on an invar bar at a distance from each other equal to the length of the specimen (30 cm.). The microscopes were first sighted on a standard-length bar kept at constant temperature, and then on the vertically suspended wires which were in contact with the ends of the specimen. Data on the thermal expansion of 40 samples of various kinds of porcelain are presented. The expansion curves of porcelains may be divided into three classes: Straight-line, concave and convex curves. The expansion curves of most materials are concave. No marked set or permanent change in dimension due to the heat treatment was observed. Porcelains having low coefficients exhibited marked resistance to sudden temperature changes. Most phenol condensation products (bakelite, condensite, formica, etc.) shrink and loose weight when subjected to temperatures above 60° C. Marble and limestone showed a permanent growth when subjected to heat treatment. On cooling below room temperature, it was found that marble has a negative coefficient of expansion. A. J. LAMBERT.

Kaolin sand. ANON. *Tonind.-Zeit.*, **44**, 593 (1920).—In washing kaolins considerable sand is removed and heretofore most of it was thrown in the waste piles. This sand is often angular and makes good sand for mortar if those particles above 7 mm. are removed. The glass industries uses that material which is free from mica. Another use is for refractory purposes. The material when finely ground is an excellent substitute for flint in stoneware, sanitary ware and porcelain. The coarse material containing mica is used for making ornamental cement ware, since the mica gives it a glistening appearance. H. G. SCHURECHT.

German clays. E. POMMER. *Tonind.-Zeit.*, **44**, 470 (1920).—In the substitution of German clays for foreign clays the use of a number of clays is approved. Although taken from the same pit, clays often vary considerably in their physical properties. Using a number of clays in a body would minimize the changes due any variations of one clay. H. G. SCHURECHT.

Kaolin as a filler for paper. ANON. *Tonind.-Zeit.*, **44**, 294 (1920).—English china clay is more refined and clean than most German kaolins, and when German kaolins are refined to the same degree of purity they may be used in the place of china clay for paper. Kaolins as a rule have a moisture content of 10 per cent whereas English china clays have a moisture content of 15 per cent. With regard to the use of German kaolin for paper making the following articles have been published in *Papier Zeit.*: (1912) 845, (1908) 1404, (1914) 2658, (1912) 2863. H. G. SCHURECHT.

Ceramic processes associated with colloid phenomena. A. V. BLEININGER. *Jour. Ind. Eng. Chem.*, **12**, 436–8 (1920).—The colloidal character of clays

was recognized as early as 1874. Recent work of Jerome Alexander in ultramicroscopic examination has shown that the Brownian movement is observed with practically every type of clay suspended in water. Upon adding solutions of salts to clays an appreciable amount of the basic ion is absorbed but practically none of the acid ion. Deeply colored solutions of metallic salts may thus be decolorized by passage through clay. In the casting process and in washing clays the addition of alkaline reagents is effective in reducing the water content required to keep the mass in the liquid condition. Coagulating reagents, acids, and salts, are used to increase the plasticity and strength of certain clays and to thicken suspensions of glazes and enamels. All the phenomena of deflocculation and coagulation occur in phases. Thus the addition of alkali to a clay suspension brings about first a decided viscosity minimum, followed by alternating maxima and minimum until finally the phases merge in a definite direction. The coagulating ions apparently increase in effectiveness proportionately with their valence. An interesting phenomena observed with clay suspensions is the electrical deposition of the particles by a direct current upon the positive electrode against the flow of water away from it. This is the basis of the invention of Schwerin for removing clay from positively charged particles (iron bearing minerals) and depositing the former upon a metallic belt or revolving drum. The migration velocity is that of the heavier ions and the voltage determines the degree to which water has been eliminated. In dealing with clays in the plastic state it seems from the researches of Bingham that we must differentiate between viscous and plastic flow in that the yield point of the former is zero and of the latter finite. The aging of clays improves their plastic working quality and it is believed that this is due in part to the formation of organic acids, caused by bacterial action or chemical processes. The addition of small amounts of reagents like Al_2Cl_6 to kaolins brings about similar results provided the material is stored for some time, but no change is observed with the more impure materials. The presence of electrolytes affects not only the magnitude of the contraction in drying but the capillary flow of the water through the clay as well. After the evolution of most of the chemically combined water in burning a clay takes up eagerly sulphur dioxide and trioxide. In this state it possesses marked catalytic properties, as in the oxidation of sulphur dioxide to trioxide, the formation of ethylene, etc. It is possible that this characteristic of dehydrated clays may find uses in the technical application of a number of chemical reactions. Although surface tension is probably the most important factor in bringing about the condensation of clays in the vitrification process, vapor pressure undoubtedly enters into the case in dealing with substances showing a vapor tension sufficiently high or in the admixture of inert materials with those of a more volatile character. In all the silicate reactions at higher temperatures diffusion through the semi-rigid mass plays an important role. A. J. LAMBERT.

Annual Report on the Mineral Production of Canada during 1918. Can. Dept. of Mines, Mines Branch, Ottawa (1919).—The 1918 mineral production of Canada as a unit and by separate provinces is shown by numerous tables. E. D. ELSTON.

Preliminary statement on the mineral production in the Province of Quebec during 1919. Prov. of Quebec, Dept. of Colonization, Mines and Fisheries, Bureau of Mines, Quebec (1920).—Statistical tables, subject to revision, set forth the mineral production of Quebec for 1919. Brief notes concerning the asbestos, chromite and magnesite industries are included in the report. E. D. ELSTON.

Bauxite and aluminum in 1918. J. M. HILL. U. S. G. S., *Min. Res.*, **1918,** Pt. 1 : 19, Mar. 16, 1920.—Notes on high-alumina clays are included in the report which is a brief résumé of the domestic and foreign bauxite and aluminum resources. E. D. ELSTON.

Talc and soapstone in 1918. J. S. DILLER. U. S. G. S., *Min. Res.*, **1918,** Pt. 11 : 24 (1920).—The imports, domestic production and world production of talc are tabulated and the occurrence, distribution and uses of talc are briefly considered. E. D. ELSTON.

PATENTS

Ceramic composition. O. GERBER. U. S. 1,336,740, April 13, 1920. A mixture of pulverulent glass, china and earthenware molded to shape and fired.

Ware-support for ceramic firing. B. B. SWINNERTON. U. S. 1,336,762, April 13, 1920. This is a sagger designed particularly for use on the trucks of tunnel-kilns, but usable in other connections. It comprises a series of open-ended tubes, rectangular in cross-section each provided with one longitudinal shelf. These tubes are adapted to be superposed and also spaced apart by distances equal to their own widths. Within these spaces other longitudinal shelves are placed thus forming in substance other saggers. When used in open fire kilns these open-ended tubes are provided with end closures.

Furnace gas-producer. L. M. UNDERWOOD. U. S. 1,337,298, April 20, 1920. Individual gas-producers are placed at each fire-box of a kiln. The fire is built upon a plurality of hollow bars each provided with a series of upstanding twyers. Steam and air are blown into these hollow bars and through the twyers into the fuel bed, at first in quantities sufficient to burn the fuel and heat the kiln. Then the amount of air is cut down and the furnace operated as a producer. Air for combustion of the producer gas is added in the bags.

Tunnel kiln. C. J. KIRK. U. S. 1,337,454, April 20, 1920. This is a twin tunnel kiln very similar to that disclosed in the patent to Kirk, U. S. 1,332,501,

March 2, 1920, with the difference that a series of vertical open-ended tile form the outer side walls of the tunnels and the convection currents set up therein prevent direct radiation from the side flues upon the ware.

Gas burner for furnaces. J. G. HESS. U. S. 1,311,515, July 29, 1919. This is a burner designed for use in a continuously operated, reversible furnace. Associated with each burner is a checker-work through which air for combustion is drawn and preheated. Two air ducts lead upward from this checker-work. The gas duct is situated above the burner, a branch flue leading down between the two hot air flues. The air and gas are led away to the burner proper and burned. By this arrangement the gas is sufficiently preheated by its passage between the hot air flues to obviate the wasteful necessity of passing it through heated checker-brick. When natural gas is used which does not require this preheating which is necessary when using producer gas, the gas may be led to the burner from the sides without passing between the hot air ducts. It is thus a relatively simple matter to change from one gas to another. The inventor claims a substantial saving per day when burning producer gas over the old double checker system with a better combustion, a brighter fire and a tendency to avoid sulphur.

Filtering compound. L. W. SHULL. U. S. 1,336,591, April 13,1920. A mixture is made comprising kieselguhr, 60–80 per cent, asbestos 10–30 per cent, and 10–15 per cent of whiting or its equivalent. The whole is made into paste with the addition of water, shaped and burned at a temperature ranging from 1800 to 3000° F. A porous body results which is said to possess the property of holding back germs and micro-organisms present in liquids filtered through it. G. E. MIDDLETON.

Refractories

The siliceous rocks. L. BERTRAND AND A. LANQUINE. *Ceramique*, **22**, 226–8 (1919); **23**, 21–3 (1920).—The use of geology in the selection of raw material for silica brick is emphasized. Silica originally occurs in nature as quartz veins and in mica schists. Secondary products resulting from the destruction of these are known as sandstone, grit stone and quartzites. Chalcedony is distinguished from quartzites by its cryptocrystalline structure. The best material used for silica brick is a quartzite from Westerwald which has a microcrystalline cement and is of the tertiary age. Quartzites of the Rhine valley are of second quality. H. G. SCHURECHT.

Zinc retorts. *Tonind.-Ztg.*, **44**, 310 (1920).—Calcined clay or porcelain (1–5 mm.) may be used as grog. Quartz produces a porous retort with a low resistance to sudden temp. change and is, therefore, not recommended. Coke is sometimes added to make the retorts more resistant to sudden temp. change. Retorts made of carborundum and zircon are very resistant to sudden temp. changes. The use of a glaze which softens at 900° C is recommended. H. G. SCHURECHT.

The reversible expansion of refractory materials. H. J. HODSMAN AND J. W. COBB. *J. Soc. Glass Tech.*, **3**, 201–22T (1919).—The problem of expansion and contraction of refractories is of first importance in the glass industry, especially as it relates to glass pots. Silica refractories, when burned, undergo a permanent expansion while fire clay refractories undergo a permanent contraction. When heated after the first burning all types of refractories undergo an expansion which is reversible on cooling. It is this reversible expansion and contraction that is here reported. The test specimens examined in an electric tube furnace were usually about 8 in. long by 1 in. diam. Expansion up to 1000° C was studied. Calcined alumina, magnesia brick, carborundum, calcined kaolin and hard calcined ball clay were found to expand fairly regularly over the whole range to 1000° C and such results do not indicate the existence of molecular changes. As contrasted with this the silica refractories (quartz) showed great irregularities. These silica refractories were found to expand fairly regularly and not much more than kaolin up to 500° C, from 500° to 600° C the expansion increased greatly and from 600° to 1000° was practically nil. The great expansion at 500° to 600° C accompanies the inversion from α to β quartz. Nothing in the results obtained was found to indicate a tridymite change between 600° and 1000°C. Fire clays in general and pot clays in particular were found to show expansions which were like kaolin on the one hand or like silica on the other hand in proportion to the silica content. Mixtures of half fireclay and half silica (about 80 per cent SiO_2 in the total mix.) behaved substantially the same as pure SiO_2. Obviously glass pots made from kaolin-ball clay mixtures or other mixtures containing little or no free SiO_2 behave very differently from pots of high silica content. The latter must be arched very carefully especially between 500° and 600° C. One point which remains unexplained is the contraction just below 600° C which occurs in the cooling of both fire clay and silica materials and which actually exceeds the corresponding expansion during heating. This is especially marked with silica and fire clays and indicates great possible danger from cracking at this point during cooling. The expansion from 0° to 1000° C was about $^1/_2$ of 1 per cent for most refractories, but for magnesia brick it was over 1 per cent. The actual figures were: alumina (plus 10 per cent ball clay for plasticity) 0.62 per cent; silica (quartzose), first heating—later heatings were slightly different, 0.68 per cent; kaolin, 0.53 per cent; ball clay, 0.57 per cent; magnesia brick, 1.27 per cent; Farnley fire clay, first heating, 0.58 per cent; Scotch fire clay, 0.61 per cent; carborundum, 0.47 per cent; equal parts of clay and ganister fired to cone 10, 0.65 per cent. C. H. KERR.

The porosity and volume changes of clay fire bricks at furnace temperatures. GEORGE A. LOOMIS. Bur. of Standards, *Tech. Paper* **159**.—This paper deals with the permanent changes in porosity and volume of clay fire bricks when reburned to temperatures at or above those to which they were originally fired. These were measured for a series of temperatures to determine what relation, if any, might exist between these changes and the

deformation of the same bricks under load at furnace temperatures. The possibility of such a relation is suggested by the fact that contraction of clay on heating and decrease in porosity are, to a certain extent, indications of the amount of softening of the mass due to the action of fluxes present and hence indicative of decreased resistance to deformation under pressure or decreased viscosity. Softening point determinations were also made to determine what relation these might bear to the results of the load test.

The results of tests on a large number of clay fire bricks from various parts of the country show that bricks which withstand a load test of 40 pounds per square inch at 1350 degrees C without marked deformation show no marked changes in porosity or volume up to 1425 degrees C. Bricks which do not withstand the test generally show appreciable contraction or expansion accompanied by considerable decrease in porosity. Bricks which showed overburning and the development of vesicular structure below 1425 degrees C, by marked expansion or increase in porosity invariably failed under load. In general, brick which show a decrease in porosity exceeding 5 per cent or a volume change exceeding 3 per cent (amounting to approximately 1 per cent in linear dimensions) when refired to 1400 degrees C fail to pass the load test.

No definite relation could be determined between the softening point of a brick and its ability to withstand pressure at high temperature. All bricks softening below cone 28 failed completely in the load test. Some showing quite high softening points also failed, probably due to the use of an inferior bond clay in the mixture or too small an amount of bonding material.

A. J. LAMBERT.

Results of some tests on refractories. M. L. HARTMAN AND O. A. HOUGEN. *Brick Clay Record*, **56**, 934 (1920).—Spalling losses were determined on various fire brick after heating to 1350° C and cooling with an air blast 10 times. Hot abrasion tests were also made by heating brick to 1350° C and holding same against a carborundum grinding wheel at a constant pressure. The depth of abrasion was then used as a means of comparison. The results obtained are as follows:

	Number of coolings	Per cent spalling loss	Abrasion inches
1 Bonded carborundum (carbofrax C)	10	0.3	0.01
2 Bonded carborundum (carbofrax B)	10	6	0.3
3 Bonded carborundum (carbofrax C)	10	8	.01
4 Grade A fire clay	10	9	.11
5 Recrystallized carborundum (refrax)	10	12	.07
6 Bauxite	10	43	.04
7 Zirconia (natural)	10	53	.06
8 Grade B fire clay	10	65	.09
9 Grade C fire clay	10	90	.07
10 Chrome	7	100	.27
11 Silica	4	100	..
12 Magnesia	3	100	2.50

H. G. SCHURECHT.

PATENTS

Ceramic composition and method of making it. W. M. W. HORN. U. S. 1,335,167, March 30, 1920. This is a so-called refractory material suitable for use in making heating elements of radiators and capable of withstanding changes in temperature between 20– and 120– C. It comprises plastic fire clay, pulverized chamotte and lean kaolin, and is substantially free from fragments of quartz and feldspar and of alkalis and alkaline earths.

G. E. MIDDLETON.

Glass

Colored hollow glassware. ANON. *Die Glas-Industrie*, **31**, 57–8 (1920). —*Yellow* is one of the difficult colors to handle. Antimony oxide, chromium and uranium oxides, iron and manganese oxides, also sulfur and carbon are used. Typical formulas are:

Dark yellow		Golden yellow	
Sand	100 kg.	Sand	100
Potash	10 kg.	Potash	5
Soda ash	25 kg.	Soda ash	30
Gypsum	16 kg.	Lime	14
Antimony oxide	1/4 kg.	"Hirse" (millet)	2 1/2
Charcoal powder	3 liters	MnO_2	3/4

Antique yellow	
Sand	100 kg.
Potash	5 kg.
Soda ash	30 kg.
Marble	18 kg.
MnO_2	5 3/4 kg.
Iron scale	2 kg.
Sulfur	300 g.

Amber yellow		Ivory yellow	
Sand	100	Sand	100
Potash	5	Soda ash	22
Soda ash	30	Saltpetre	4
Lime	15	Feldspar	18
Saltpetre	2	Fluorspar	12
Antimony oxide	1/4	Kryolite	10
Sodium uranate	1/2	MnO_2	4
		Red lead	4
		Iron oxide	1

Brown.—MnO_2 and Fe_2O_3 are commonly used, also carbon and the organic materials like millet ("hirse") flour, etc.

Brown	
Sand	100
Soda ash	33
Lime	10
MnO_2	14
Powdered coke	1

Fiery brown	
Sand	100
Soda ash	33
Lime	16
Powdered coal	1
Flour	3/4

Reddish brown	
Sand	100
Soda ash	33
Lime	15
Fe_3O_4	1 3/4
MnO_2	9 1/2

Fawn colored	
Sand	100
Lime	5
Potash	38
Bone ash	22
Iron oxide	2

Gray.—A neutral gray is obtained by using: Sand, 100; potash, 10; soda ash, 23; lime, 14; nickel oxide, 1 1/2; iron oxide, 2; copper oxide, 1; cobalt oxide, 1/5 kg. *Violet* is obtained by using MnO_2 and Fe_2O_3. *White* glasses are made from the following:

Milk glass	
Sand	100 kg.
Soda ash	12 kg.
Potash	5 kg.
Feldspar	15 kg.
Fluorspar	10 kg.
Saltpetre	2 kg.
Kryolite	10 kg.
Nickel oxide	4 gr.

Milk glass	
Sand	100
Soda ash	15
Feldspar	18
Fluorspar	9
Kryolite	8
Tin oxide	4

Enamel glass	
Sand	100
Potash	20
Saltpetre	5
Tin oxide	12
Red lead	80
Borax	4
Bone ash	12

Opalescent glass	
Sand	100
Soda ash	30
Feldspar	35
Fluorspar	18
Red lead	6
Nitre	4
Borax	0.5

C. H. KERR.

The polariscope and its application to the glass industry. G. V. WILSON. *J. Soc. Glass Tech.*, **3**, 256–8 (1919).—A polariscope consists of two essential parts, a polarizer and an analyzer. In the instrument described the polarizer consists of a pile of 10 or 12 clear, thin glass plates the bottom one blackened on the back. Polarized light is reflected to a Nicol prism, the analyzer. Glass objects placed between these show light transmitted in proportion to the amount of strain. By inserting a plate of selenite of suitable thickness between the analyzer and the test sample slight strains can be detected because the differences in color are accentuated. Sketches are given.

C. H. KERR.

The annealing temperatures of magnesia-soda glasses. S. ENGLISH AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **3**, 278–8 (1919).—The compositions of the glasses tested are shown in the following abstract (on MgO-Na_2O glasses, Davidson, Hodkin and Turner). The analyses follow:

Glass No.	SiO_2	Na_2O	MgO	Minor constituents (CaO, Fe_2O_3) and Al_2O_3	Total
24	74.07	24.23	1.10	0.37	99.87
25	74.35	23.46	1.85	.75	100.41
26	75.00	22.12	2.49	.26	99.97
27	75.16	20.69	3.47	.46	99.78
28	75.19	19.83	4.20	.52	99.74
329	76.30	18.26	5.09	.74	100.39
330	77.09	16.05	6.10	.68	99.92
331	76.68	15.77	6.87	.93	100.25
332	76.86	14.55	7.46	.93	99.80
389	77.77	13.40	8.45	056	100.17
390	78.28	11.76	9.30	.91	100.25

The following table shows annealing temperatures with comparisons for similar lime-soda glasses.

Magnesia-soda glasses			Lime soda glasses		
Glass No.	Molecular percentage of magnesia (MgO)	Annealing temperature	Glass No.	Molecular percentage of lime	Annealing temperature
1	...	490°	1	...	490°
24	1.66	495	2	1.62	496
25	2.77	502	3	2.81	501
26	3.71	505	4	4.11	508
27	5.16	510	5	4.84	512
28	6.23	519	6	6.73	526
329	7.48	524	7	8.00	538
330	8.95	530	8	8.75	552
331	10.02	543	9	10.01	562
332	11.01	560	10	11.14	581
389	12.21	583	11	12.41	601
390	13.38	616	..	...	...

Curves drawn from these data show while the annealing temperatures are lower for the magnesia glasses, especially so in the softer glasses, with harder glasses, the annealing temperature rises faster in the magnesia than in the lime glasses and with very hard glasses might be about the same. However, within practical limits in ratio of soda to magnesia or lime, the magnesia glasses anneal at appreciably lower temperatures. If, in commercial glasses dolomitic lime is used in place of high calcium lime, a more ready annealing, may be expected. C. H. KERR.

Magnesia-soda glasses. J. H. DAVIDSON, F. W. HODKIN AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **3**, 275–7 (1919).—Although magnesia is present in many glasses and often in considerable amounts still magnesia glasses, as such, are not yet of commercial importance. Magnesia-soda glasses of the following compositions were tried. All temps. are C.

Glass No.	Approx. molecular composition	Working properties
24	$6SiO_2$, 1.9 Na_2O, 0.1 MgO	At 1100–1200° very mobile. Did not cool so rapidly as the corresponding lime-glass.
25	$6SiO_2$, 1.8 Na_2O, 0.2 MgO	Very mobile at 1200–1300°, but worked well.
26	$6SiO_2$, 1.7 Na_2O, 0.3 MgO	Similar to 25. Retained its heat for considerable time.
27	$6SiO_2$, 1.6 Na_2O, 0.4 MgO	Similar to 26.
28	$6SiO_2$, 1.5 Na_2O, 0.5 MgO	Worked well and retained its heat.
329	$6SiO_2$, 1.4 Na_2O, 0.6 MgO	Worked well at 1150–1200°. Thick foam on surface of glass requiring to be removed.
330	$6SiO_2$, 1.3 Na_2O, 0.7 MgO	Worked well at 1150–1250°. Rather viscous and needed temperature of 1300° to enable to pour. Slight scum.
331	$6SiO_2$, 1.2 Na_2O, 0.8 MgO	Melted 1400–1450°. Worked well at 1250–1350°. Viscous and stiff, but drew evenly into rod and tubing.
332	$6SiO_2$, 1.1 Na_2O, 0.9 MgO	Smilar to 331, but more viscous.
389	$6SiO_2$, 1.0 Na_2O, 1.0 MgO	Metal very viscous even at 1400°, and inclined to be seedy and cordy. Tubing difficult to draw.
390	$6SiO_2$, 0.9 Na_2O, 1.1 MgO	Very viscous. Boil difficult to remove even after 22 hours. Scum on surface. Easy enough to gather, but too stiff to draw even at red heat, and tubing and rod not good.

Glasses Nos. 28 to 389 had a light blue tint. In general the magnesia glass closely resembled corresponding lime glasses. In large amounts it made melting difficult. There were, however, distinct differences. The viscosity of high magnesia glasses was greater than that of high lime glasses but the rate of change in viscosity seemed to be less than with the lime glasses. Magnesia glasses retained their heat longer. They also showed a tendency to to raggedness or stringiness and a greater tendency to cordiness. The chief apparent advantages of magnesia glasses over lime glasses were: (1) retention of heat, (2) larger working range, (3) lower coefficient of expansion and (4) lower annealing temperature. A study of magnesia glasses may prove fruitful. C. H. KERR.

The influence of lime on the value of Young's modulus of elasticity for the soda-lime glasses. J. R. CLARKE AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **3**, 260–6 (1919).—Young's modulus of elasticity is defined as the ratio of the stress applied to the strain which the object undergoes. This ratio is obviously very important for the amount of strain that can be developed in a glass without fracturing it, is related to the elasticity. The method of determination was to observe the bending of a glass rod supported at the ends and weighted at the middle. The value for Young's modulus (E) was calculated as $100 \times l^3 \div 12 \times r^4 d$ where l = distance in cm. between knife edges, r = radius of the rod and d = mean depression for 100 grams weight. The results are shown in the following table.

Glass	Composition						Value of E
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	
1.....	74.25	0.42	0.16	Trace	..	25.37	5784 kg./mm.^{2}
2.....	73.90	.21	.14	1.57	..	23.80	5930 kg./mm.^{2}
3.....	74.05	.22	.14	2.63	..	23.00	6175 kg./mm.^{2}
4.....	74.02	.29	.15	3.79	..	23.15	6332 kg./mm.^{2}
5.....	73.77	.34	.18	4.54	0.16	20.78	6426 kg./mm.^{2}
6.....	73.21	.55	.62	6.22	.22	19.38	6700 kg./mm.^{2}
7.....	73.97	.76	.18	7.56	.23	17.30	6804 kg./mm.^{2}
8.....	74.82	.38	.09	8.15	.26	16.30	6965 kg./mm.^{2}
9.....	74.92	.38	.17	9.26	.31	14.88	7034 kg./mm.^{2}
10.....	74.59	.48	.17	10.40	.29	14.22	7249 kg./mm.^{2}
11.....	74.93	.38	.16	11.63	.31	13.02	(6912) kg./mm.^{2}
12.....	($6SiO_2$, 1.1 CaO, 0.9 Na_2O)						7642 kg./mm.^{2}
16.....	66.67	1.43	.32	18.06	.85	12.72	8343 kg./mm.^{2}

Values for E were also calculated from the compositions, using Winkelmann and Schott's factors, but these factors were found to be inaccurate. A comparison of the old and new factors is shown in the table:

Oxide	W. & Schott's factor	New factor
SiO_2	65	40
Na_2O	100	110
Al_2O_3	160	120
Fe_2O_3	...	120
CaO	100	240
MgO	500	300

Using these new factors in calculating E gives results close to those determined experimentally.

The general conclusions are: (1) increases in lime cause a corresponding and very marked increase in elasticity, (2) Winkelmann and Schott's conclusion, indicated by the factors assigned, that soda and lime are alike in their effects on elasticity, is shown to be incorrect, (3) Young's modulus of elasticity can be satisfactorily calculated from composition, using the new factors given above. C. H. KERR.

Glass for table working. M. W. TRAVERS. *J. Soc. Glass Tech.*, 253–6 (1919).—Many years ago a German manufacturer stated that he made two kinds of lamp-working glasses, one deteriorated if kept over six months before working while the other was good for years. More recently many samples of both good and bad were submitted by an English firm and analyses showed that "the high quality glasses contained both soda and potash, while the low quality glasses contained soda alone." The author, therefore, recommended that glass for table-working tube be made to approximately the following composition: silica, 68; alumina, 4; calcium oxide, 7.5; potassium oxide, 7; sodium oxide, 13 per cent. From a lamp-working standpoint the glass is good but it plains only at a high temperature and it is expensive. An unusually fine piece of old table-working glass analyzed: silica, 61.26; alumina, 7.92; calcium oxide, 9.25; potassium oxide, 2.98; sodium oxide, 1.08; antimony oxide, 3.45 per cent. A glass of such composition may be made by using feldspar and without adding potash in any other form. This seems to offer distinct possibilities. C. H. KERR.

A simple apparatus for the detection of strain in glass. S. ENGLISH. *J. Soc. Glass Tech.*, **3**, 258–60 (1919).—A home-made polariscope is described with all details necessary for construction. C. H. KERR.

Note on the formation of glass. S. C. BRADFORD. *J. Soc. Glass Tech.*, **3**, 282–5 (1919).—"Although it has been customary for years to regard glass as a supercooled liquid" the supposition is not helpful and "does not conform to the dictionary definition of a liquid as being in a state in which its particles are free to travel about." There is no sudden change when glass solidifies —the gradual change resembles the setting of a jelly. "The structure of gels is beginning to be understood and similar considerations appear to explain the formation of glass." "There are many indications that the solidification of glass is a crystallization process." "The development of visible crystals is dependent on the velocity of crystallization" and glasses, because of low heat conductivity and viscosity, have a very small velocity of crystallization which permits a great degree of overcooling. Evidences point toward glass as a crystalline formation. Physical properties are influenced least by monovalent ions, more by divalent ions, etc., the effects increasing enormously with valence. Opal glasses illustrate this. Another point is the effect of alkali on color development. For example, three glasses with nickel as coloring material and otherwise alike except for the nature of the alkali will show a fine deep violet with potash, a near-brown with soda and a yellowish brown with lithia. A study of glass as a crystalline product "might lead to useful results." The arguments are strong. C. H. KERR.

Some experiments on glass for lamp-working purposes. J. D. CAUWOOD, J. H. DAVIDSON, F. W. HODKINS AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **3**, 266–74 (1919).—Attempts were made to produce glass suitable for lamp-

working, basing the results on analyses of six good foreign glasses. The analyses of these glasses follow:

	(1)	(2)	(3)	(4)	(5)	(6)
SiO_2	69.30	69.10	71.88	68.78	61.26	71.90
As_2O_5	Trace	0.10	0.10	..	...	..
Sb_2O_3	...	..	..	0.52	3.45	0.48
Al_2O_3	4.05	3.10	2.75	4.04	7.92	3.69
CaO	8.28	6.89	4.90	7.75	9.25	7.99
MgO	0.07	0.20	0.20	0.34	0.20	..
K_2O	4.96	6.38	1.98	2.60	3.98	0.32
Na_2O	12.80	14.50	18.57	15.72	13.08	14.90
MnO	0.20	0.10	0.10	0.20	0.30	0.75
Fe_2O_3	.18	..	..	.25	.30	.31
	99.84	100.37	100.48	100.20	99.74	100.34

Glasses corresponding to analyses 1 to 3 were the best all around lamp-working glasses and especially those based on No. 2. The best glass made was from batch: sand, 1000; feldspar, 367; limestone, 220; soda ash (95 per cent), 448; potash, 151; magnesia (90 per cent), 3.7; manganese (87 per cent MnO_2), 2.75 lbs. This is very similar to a German lens glass for artificial eyes, which was reproduced by a batch: sand, 1000; feldspar, 300; limestone, 110; soda ash (95 per cent), 375; potash (92 per cent), 205; magnesia, 10; white arsenic, 5; manganese, 3 lbs. Results indicate that arsenic and antimony should be omitted from lamp-working glasses for they seem to cause blackening when worked in the flame. The addition of nitre had no influence upon this tendency to blacken. Apparently this tendency is not due to lead impurity in the arsenic or antimony. Possibly glasses of distinctly different type also may be very good for lamp-working and experiments are under way. There are indications that a high lime glass may be good. In one set of tests a glass with equal molecular proportions of soda and potash worked very well. C. H. KERR.

The durability of lime-soda glasses. J. D. CAUWOOD, J. R. CLARKE, CONSTANCE M. M. MUIRHEAD AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **3**, 228–37 (1919).—Glasses with less lime than in the glass 1.5 Na_2O, 0.5 CaO, 6 SiO_2 are not resistant to the attack of reagents including water, caustic alkali, sodium carbonate and hydrochloric acid—that is glasses made from batches varying between (*a*) sand 1000, soda ash 590 and (*b*) sand 1000, soda ash 441, limestone, 139 are unsatisfactory. Such glasses are not only dissolved by reagents but are hydroscopic. Substituting lime for soda increased resistance to all kinds of liquids. In glasses containing only a very small amt. of lime, water is the most corrosive reagent and strong caustic alkali the least. For the production of a fairly rapid melting glass suitable for automatic or semi-automatic machines batches varying from sand 1000,

soda ash 412, limestone 166, to sand 1000, soda ash 353, limestone 194 are satisfactory. The glasses are sufficiently durable for ordinary use.

C. H. KERR.

The manufacture of table ware in tank furnaces. R. L. FRINK. *J. Soc. Glass Tech.*, **3**, 242–9 (1919).—Flint glass as here referred to is meant to include all glasses having composition between the limits, silica 78, lime 6, soda plus potash 16, and silica 62, lead oxide 26, potash plus soda 12 per cent. Flint glasses are divided into two classes: lead flints, including optical glass, bulb glass, cut-glass blanks, table ware; and lime flints, including bulb glass, blown stem ware, pressed ware, blown ware (as chemical ware, vases, chimneys) pressed cutting blanks and blown pressed ware both hand and machine made. The old idea that lead glass could not be successfully melted in a tank furnace on account of reduction of the lead has been proven erroneous for good results are obtained. Furnace operators who have been trained in pot furnace work where a long reducing flame is maintained have difficulty in learning to operate a tank requiring oxidizing conditions. It is claimed that when soda or potash or a combination of the two exceeds 17 per cent it is very difficult to make glass free from striae and capable of ready annealing. If producers are used for tank furnaces an ample and uniform quantity of gas should be provided. Additional requirements for successful work include (1) air supply at suitable temperature to effect complete combustion, (2) prompt removal of gases of combustion, (3) unconsumed gases must not come in contact with melting batch, (4) no furnace should deliver less than 9 lbs. of glass per sq. ft. of melting area per hr. to insure first quality glass.

C. H. KERR.

A proposed standard formula for a glass for lamp-workers. F. W. BRANSON AND F. H. BRANSON. *J. Soc. Glass Tech.*, **3**, 249–53 (1919).—A pre-war imported tubing which was entirely satisfactory analyzed: SiO_2 69.64; Al_2O_3, 3.02; Fe_2O_3, 0.06; MnO, 0.18; CaO, 6.40; MgO, 0.37; K_2O, 6.98; Na_2O, 13.36. No Sb_2O_3 or As_2O_3 were present. The new standard formula developed from the basis of this analysis and known as batch No. 6 is as follows: sand, 1104; potash feldspar, 400; limestone, 222; saltpetre, 213; soda ash (95 per cent), 410; manganese (87 per cent MnO_2), 3. This glass is quite suitable for the making of plugs, stopcocks, bulbs, and so forth, and may be re-blown many times without devitrification. In exptl. melts 56 lbs. pots with 31 lbs. of batch added were maintained at 1340° C for 14 hrs. Analysis of finished glass gave: SiO_2, 70.35; Al_2O_3, 4.06; Fe_2O_3, 0.04; MgO, 0.36; CaO, 7.1; MnO, 0.16; K_2O, 6.85; Na_2O, 10.66.

C. H. KERR.

The properties of lime-soda glasses. J. H. DAVIDSON AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **3**, 222–7 (1919).—The lime-soda glasses are by far the most important commercially. Glasses with almost any proportion of these three ingredients, silica, lime and soda, can be made if sufficient melting power is available but most commercial glasses approach the formula CaO, Na_2O,

6 SiO_2. The ratio of CaO to Na_2O may vary considerably but usually the relationship is adhered to of 3 molecules of SiO_2 to one of CaO and Na_2O combined. Expts. were carried on to determine the working properties of glasses varying from 2 Na_2O, 6 SiO_2 to 1 Na_2O, 1 CaO, 6 SiO_2 also of two commercial glasses containing 0.81 Na_2O, 1.18 CaO, 3.94 SiO_2 and 0.75 Na_2O, 1.25 CaO, 4.63 SiO_2. Experiments with pots holding 28 lbs. were hardly satisfactory—with 56-lb. pots the results were good. While lime-containing glasses have usually been regarded as readily devitrified these experiments showed that devitrification decreased as lime increased. Glasses with less CaO than in the glass 1.5 Na_2O, 0.5 CaO, 6 SiO_2 should be avoided. Glasses from 1.4 Na_2O, 0.6 CaO, 6 SiO_2 to 1 Na_2O, 1 CaO, 6 SiO_2 are all durable. For semi-automatic machines glasses from 1.4 Na_2O, 0.6 CaO, 6 SiO_2 to 1.2 Na_2O, 0.8 CaO, 6 SiO_2 are recommended. These simple batches may not be the best but serve as a basis for adding small amts. of other materials. Some alumina from feldspar or clay should usually be added. Glasses with about 1 Na_2O, 1 CaO, 6 SiO_2 or one of the two commercial glasses given above are recommended for tanks with hand operation because they set rapidly.

C. H. KERR.

The glass furnace—a contribution to the saving of fuel. ANON. *Sprechsaal*, **53**, 66–7 (1920).—The chief use of fuel is in the melting furnace and great economies can be effected by proper furnace design. In recuperative furnaces only the air is preheated while in regenerative furnaces both air and gas are preheated, hence the regenerative type is more economical. Many details of furnace design, especially flues, are discussed. C. H. KERR.

The use of peat in the glass industry. A. F. WUROMUS. *Sprechsaal*, **53**, 46–7 (1920).—Ash varies greatly from 5 to 50 per cent. Water content of good air-dried peat is 10–20 per cent. When handled by machine it is commonly made into bricks about 6 x 3 x 11 inches, weighing about 6 lbs. each. Drying may be done artificially or naturally, the air-dried peat being better. Peat with moderate ash and water contents is readily burned in gas producers and if water or ash is high some wood may be used with the peat. A 10-pot Siemens furnace operated with 3 producers will use 10–12,000 lbs. of good peat (and no wood) per 24 hrs., or if a poorer peat is used it will take 12–14,000 lbs. peat plus $^2/_3$ of a cord of beech wood. With peat the flues must be cleaned out frequently. C. H. KERR.

The characteristics of striae in optical glass. T. T. SMITH, G. E. MERRITT AND A. H. BENNETT. Bur. of Standards, *Sc. Paper* **373**.—Striae are imperfections in optical glass which are revealed by, and cause consequent damage because of, their refractive index being slightly different from the surrounding glass. Various methods for detecting their presence are described and photographic illustrations by a highly sensitive method given. The comparative effects of striae on the definition given by binolcular prisms, in which striae are present in different degrees, are exhibited by photographs of an artificial

star taken through these prisms. Prisms which had been discarded because of the presence of striae in them, except where these show up in dense nests, were found to give as good definition as those having no appreciable striae. The refractive indices of the striae were measured for a number of samples by a total reflection refractometer and found to be above or below that of the surrounding glass by about 2 in the fourth decimal place. From the investigation, it is concluded that in most visual work a few striae do real damage only when in focus or nearly in focus in the field of view. The scattering effect of a few striae is probably detrimental only in astronomical and certain kinds of microscopic work. A. J. LAMBERT.

A deposit of granulite in Devonshire, *London Times Trade Supplement*, April 10, 1920.—A very large deposit of granulite has been discovered near Okehampton, Devonshire, England. Granulite contains silica, potash, soda, and alumina, and its use is economical in the production of glassware. An experimental furnace has been in use for some time, two others are being constructed, and it is anticipated that the commercial manufacture of glass will commence almost immediately. It is reported that it will be possible to manufacture glass bottles and jars very cheaply. The estimated cost of the material utilized on the spot amounting to 15s. 0d. (at normal rate $3.65) per ton, compared with a cost of 2 pounds ($9.73) per ton for the cheapest mixtures ordinarily used for making glass bottles.

A. J. LAMBERT.

The heat expansion of soda-lime glasses. S. ENGLISH AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **3**, 238–41 (1919).—In all glass making, especially in annealing, coeff. of expansion is important. Coeff. for glass under strain is higher than for the same glass when free from strain. Results of coeff. detns. on a series of glasses show that decreasing Na_2O and increasing CaO decreases the coeff.

	Approx. mol. composition			Coeff. of linear expansion	Temp. range
1	6 SiO_2	2.0 Na_2O	..	0.000001153	25.0–90.0°
2	6 SiO_2	1.9 Na_2O	0.1 CaO	.000001106	25.3–89.8
3	6 SiO_2	1.8 Na_2O	.2 CaO	.000001065	25.1–89.1
4	6 SiO_2	1.7 Na_2O	.3 CaO	.000001021	25.3–89.8
5	6 SiO_2	1.6 Na_2O	.4 CaO	.000000988	25.1–90.0
6	6 SiO_2	1.5 Na_2O	.5 CaO	.000000947	24.6–90.6
7	6 SiO_2	1.4 Na_2O	.6 CaO	.000000911	25.0–90.0
8	6 SiO_2	1.3 Na_2O	.7 CaO	.000000870	25.0–90.0
9	6 SiO_2	1.2 Na_2O	.8 CaO	.000000844	25.0–89.9
10	6 SiO_2	1.1 Na_2O	.9 CaO	.000000810	25.0–90.0
11	6 SiO_2	1.0 Na_2O	1.0 CaO	.000000769	24.0–90.6
16	3.94 SiO_2	0.81 Na_2O	1.18 CaO	.000000882	25.0–89.5
17	4.68 SiO_2	.75 Na_2O	1.25 CaO	.000000801	25.0–90.0

The relation between compn. and coeff. is thus shown to be represented by a straight line. Schott's factors for calculating coeff. of expansion from compn. are shown by the following table to be inaccurate or at least to be of narrow application.

Glass No.	Calculated by Schott's rule	Experiment	Difference
1	1053	1153	—100
2	1036	1106	— 70
3	1013	1065	— 52
4	993	1021	— 28
5	981	988	— 7
6	958	947	+ 11
7	916	911	+ 5
8	886	870	+ 16
9	862	844	+ 18
10	850	810	+ 40
11	822	769	+ 53
16	923	881	+ 42
17	789	801	+ 12

C. H. KERR.

Glass pots. A. SIEBEL. *Tonind.-Ztg.*, **44**, 303–4 (1920).—Stones in glass are often caused by highly aluminous flint clay which becomes detached from the pot through the solution of the more siliceous bond clay. The practice of using a highly aluminous flint clay for grog is criticised and the use of grog having the same composition as the bond clay is recommended, since the solution by the glass would be uniform in this case thus eliminating the possibility of stones to a large extent. H. G. SCHURECHT.

Composition of Belgian table glass. *Schnurpfeil's Review for Glass Works*, **3**, No. 35, 549.—Sand 100 kg., carbonate of soda 33 kg., carbonate of lime 17 kg., nitrate of soda 3.5 kg., salt 1.5 kg., antimony oxide 150 gr., arsenic 150 gr., manganese 200 gr., cobalt oxide $^1/_3$ to $^1/_2$ gr.

R. J. MONTGOMERY.

Composition of brown bottle glass. *Schnurpfeil's Review for Glass Works*, **3**, No. 35, 551.—Sand 100 lbs., soda ash 34 lbs., lime 25 lbs., sulphate of soda 1 lb., calcined oats 1 lb., charcoal 8 oz. R. J. MONTGOMERY.

Mosaic and enamels of the vatican. ANON. *Pottery Gaz.*, **45**, 518–9 (1920).—The mosaic is composed of glass and minerals. When the glass has melted the colored powders and minerals are added and thoroughly mixed after which they are slowly baked. The enamel is then taken out and molded into small palettes. To make a picture the artist takes a highly polished slab of plaster and sketches the picture with charcoal. With a piercer he then hollows out around the design leaving small holes in which a glue or "smalt" is placed. The mosaic cubes are then chipped to fit in these holes by means of small hammers. H. G. SCHURECHT.

Machine making of window glass. DR. WENDLER. *Die Glas-Inaustrie*, **31**, 33–4, 41–2, 49–50 (1920).—An historical résumé of machine methods, chiefly American. C. H. KERR.

A note on blue glass. J. W. MELLOR. *Trans. Eng. Ceram. Soc.*, 18, 478–80 (1919).—Adding a few per cent Co_2O_3 to lamp bulb glass was found to cause filaments, viewed through such glass, to appear red. It was desired to cut out these red rays. CuO was not satisfactory but a small amt. of Cr_2O_3 with the Co_2O_3 proved satisfactory. Absorption spectra are shown. C. H. KERR.

PATENTS

Machine for making carboys or large glass containers. H. M. BROWN. U. S. 1,334,647 and 1,334,648, March 23, 1920. These machines are designed for making carboys or other large containers provided with internally threaded mouth portions. Glass is forced into a mold in contact with the neck of a newly formed carboy and around a collapsable, threaded mandrel. The molten glass for the mouth portion welds with the neck of the carboy. The mandrel is rotated to thread the mouth of the carboy internally, collapsed and withdrawn.

Method of manipulating glass. F. L. O. WADSWORTH. U. S. 1,334,725, March 23, 1920. As molten glass flows downward from an orifice into succession of molds, the stream is periodically cut to allow charge of the proper amount to fall into the waiting molds. The cutting blades used here when brought together form a conoidal pocket in which the arrested stream gathers, swells laterally and is chilled. The blades are then separated and this enlarged gob allowed to fall into a mold.

Conveyor for glass-ware. J. L. HIATT. U. S. 1,334,453, March 23, 1920. Molded articles of glass are placed upon a conveyor and moved, single file, onto the surface of a rotary disc at the mouth of the leer, the lineal speed of the disc being less than that of the conveyor whereby the articles are closely assembled. When substantially half the peripheral surface of this disc has been filled, a rotating arm sweeps the articles off upon the forwardly moving leer pan.

Method and apparatus for drawing and annealing sheet-glass. W. S. TEMPLE and J. A. KEALEY. U. S. 1,334,569, March 23, 1920. A plain sheet of glass is drawn vertically upwardly from the tank and through a vertical leer without coming into surface contact with anything. A bait is used to initiate the draw but thereafter vertical moving chains carrying clamping devices support the edges of the sheet and carry it upward. As the sheet approaches the top of the leer parts are cut off and removed. The operation is thus continuous.

Glass-blowing apparatus. F. W. STEWART. U. S. 1,335,533, March 30, 1920. By means of this apparatus, the blower, when standing upon an ele-

vated platform with this mold located below is able to control, by means of pedals, both the mechanism for opening the mold and the spraying device, whereby, unaided, he is able to operate both the mold-opening device and the spraying device, and thus can dispense with the extra boy usually employed for this purpose.

Process of making vacuum bottles. C. F. P. ANDERS. U. S. 1,335,544, March 30, 1920. The inner and outer receptacles are made of such shape and size that the inner may be inserted through the upper end of the outer and supported by an interposed spiral spring at the base thereof while the two are joined at their upper edges. This arrangement makes for simplicity of operation.

Apparatus for drawing glass cylinders. J. H. CAMPBELL. U. S. 1,335,653, March 30, 1920. A series of drawing units is provided, each unit composed of two fixed but independent pots, a single movable heater for the two pots, a drawing apparatus for each pot, and a single shiftable hoist for each unit.

Vial-machine. H. F. HAGEMEYER. U. S. 1,335,733, April 6, 1920. This machine acts on glass tubing making therefrom glass vials. The blank tube as received by the machine contains material for two vials. It is heated at its middle, necked-in, divided into halves, the inner and opposing ends of these halves bottomed and then the outer ends formed into the ordinary lip or a screw neck.

Automatic take-off device for glass-blowing machines. H. C. FENTRESS. U. S. 1,336,028, April 6, 1920. Grab arms for the glass-blown articles are mounted upon a rotary table which rotates in synchronism with the rotary table upon which the articles are blown. As these tables rotate the newly blown articles are seized by the grab arms and transferred to any desired receiver.

Method of and apparatus for drawing glass. A. E. SPINASSE. U. S. 1,336,056, April 6, 1920. A hollow, fluid-cooled drawing ring is immersed at the drawing surface and the cylinder drawn from the space enclosed thereby. The size of cylinder may be regulated by degree of immersion and cooling of the ring which in turn determines the area of glass which is chilled and rendered viscous.

Transfer mechanism for fruit-jar machines. U. S. 1,336,317, April 6, 1920. In making glass fruit jars the iron ring with the glass attached is transferred from the press table to the blow table when the jars are formed by the blowing apparatus. The transferring means consists of an arm provided with hooks for engaging the iron rings. These hooks are replaced by electromagnets according to this invention.

Burner for fire-polishing glassware. J. M. SAID. U. S. 1,337,328, April 20, 1920. This is a burner designed for fire-polishing glassware on the press

and before removal from the molds. The flame is given a swirling motion which completely envelopes the work.

Glass shaping and blowing machine. E. ROIRANT. U. S. 1,337,723, April 20, 1920. The parison, neck and finishing molds of this machine have opening and closing movements only and none of translation. Molten glass is drawn up through the bottom of the parison mold from a movable container. The bottom mold is then raised to support the parison, the parison mold is opened and the halves of the finishing mold swung into place. Thereupon the bottle is blown. Then the finishing mold is opened and the bottom mold descends bearing the bottle. G. E. MIDDLETON.

Whiteware and Porcelain

On the elastic modulus of glazes. WALTER STEGER. *Keram. Rdsch.*, **27,** 313–6 (1919); *Chem. Ztblt.*, No. 7, 1920.—The elastic modulus and thermal coefficient of expansion for 11 glazes was determined between room temp. and 100°. The values for the former lie between 5730 and 6830 /qmm. Glazes containing Pb have lower moduli than Pb free glazes. The modulus of normal Pb glazes is more strictly dependent upon chemical compn. than in the case of Pb-free glazes. The values obtained exhibit considerable differences from the constants determined by Winkelmann-Schott and from these observations it cannot be established whether there is a relation between the elastic modulus of a glaze and its compn. H. G. SCHURECHT.

The dust question in the porcelain industry. F. KOELSCH. *Sprechsaal*, **53,** 147–9, 155–7 (1920).—It has been found that the dust in porcelain factories has in many cases caused tuberculosis and catarrhal diseases. The analyses of the dust in various parts of a porcelain factory showed 83–266 mg. of dust in 1 cm. of air. The following remedies are suggested for reducing the dust evil: (1) Enclosing those parts causing the most dust from the rest of the factory; (2) removing the dust by suction; (3) frequent sprinkling of the floors to settle the dust; (4) employees should change clothes often and (5) the employees working in dusty rooms should have short hours and overtime should be forbidden. H. G. SCHURECHT.

Defective ware in the casting of porcelain. O. ROSE. *Sprechsaal*, **53,** 155 (1920).—Some of the common troubles with cast porcelain are uneven and warped surfaces. The trouble may often be traced to grinding the body too fine or to adding too much soda to the slip. One course of error often overlooked is the plaster mold which should absorb the water uniformly from the slip. In making molds the plaster should be constantly stirred until it thickens to prevent lumps of plaster having a different density than the rest of material. H. G. SCHURECHT.

Cooking wares. K. ELEOD. *Pottery Gaz.*, **45,** 510 (1920).—In the Sept. No. of *Ceramique* a recipe for a cooking ware body is given as follows: (1) China clay (kaolin) of Planards, by Saint Vallier; (1) china clay (kaolin)

of Dieulefit (Drome); (1) China clay of Auberives (Isere). The ware is biscuited at cone 08. The ware is covered with a thin coat of water glass before dipping into a fritted glaze which consists of borax 30; boric acid 20; pure flint 5; porcelain glaze 15; whiting 30 and matures at cone 02. The above was tried with Eng. china clay but it was found necessary to fire the biscuit to a higher temp. H. G. SCHURECHT.

English china clay for hard porcelains. ANON. *Pottery Gaz.*, **45,** 513 (1920).—Rieke (*Sprech.*, **1915,** 21–3) and Mellor are extensively quoted. R. found that Eng. china clay contains less fine material than the other kaolins tested. It also contains less $TiO_2 + Fe_2O_3$ and has a whiter color than most clays. H. G. SCHURECHT.

Dry grinding versus wet grinding. K. ELEOD. *Pottery Gaz.*, **45,** 510 (1920).—The non-plastic materials in Amer. earthenware bodies are ground too coarse. Dry grinding is better than wet grinding and cylinder grinding is more economical than pan grinding. The elutriation test does not classify the extremely fine material and, therefore, is merely a measurement of the coarseness rather than the fineness. H. G. SCHURECHT.

Lime in earthenware bodies. A. HEATH AND A. LEESE. *Pottery Gaz.*, **45,** 502–3 (1920).—To determine if the use of lime in earthenware bodies causes crazing of the glaze, bodies of the composition ball clay 30, china clay 25, flint 30, and stone 15 were tested in which the stone was replaced by varying percentages of lime. The trials showed no signs of crazing after two years. A body of the composition ball clay 30, china clay 25, flint 30, stone 8.25 and whiting 6.75 was then tried and glazed with a factory glaze and it was found that the trials crazed badly. A fritted lead glaze was then tried and it gave better results on the porous bisque pieces while the glazes on hard fired trial pieces again crazed badly. By increasing the alumina, silica and boric acid a glaze was developed which did not craze on the hard fired bisque pieces but the maturing temp. was too high practice. By the use of this special glaze good results were obtained with bodies containing as high as 15 per cent whiting. H. G. SCHURECHT.

The china clay industry of west England. H. F. COLLINS. *The Mining Magazine*, **21,** 269–75, 329–37 (1919); **22,** 25–32, 94–7 (1920).—Although deposits of china clay and china stone occur in several areas in the west of England, the Hensbarrow district, north of St. Austell is the principal producing area. The occurrence, origin and form of the deposits are discussed. Much space is given to methods of mining, purification, preparation for market, and uses of the materials. Analyses, tables of production, photographs and tabulated body formulae are included. The conditions of the industry are dealt with at some length. E. D. ELSTON.

White earth, its competition with China clay. ANON. *Brit. Clayworker*, **29,** 18–9 (1920).—Owing to the increased price of china clay, the competition

of white clays such as are found in America, France and Germany is becoming keener. Some merits claimed for the English china clay are as follows: They are extremely fine grained as most washed china clays will easily pass a 120-mesh sieve. Owing to its freedom from potash it makes an excellent material for porcelain. The increased use of china clay for sizing of cotton goods is due to its adhesiveness and weight, which are given to a size of flour and clay. These advantages are not attainable to the same extent with other materials. Its use in paper is becoming increasingly popular with paper manufacturers as loader and filler, because it not only effectively fills up the interstices between the fibers of the pulp, but is readily incorporated with the fiber, and adheres so tenaciously to it that vigorous teasing in water will not separate it. It is also stated that china clay has a greater affinity for printers ink than any other material used for filling purposes. H. G. SCHURECHT.

Various problems in the porcelain industry. F. SINGER. *Dingler's polytech. J.*, **9**, 96–101 (1920).—Glazes for chemical porcelain were made more resistant to chemical reagents by increasing the silica and alumina contents. In high tension porcelain insulators it was found that the coeff. of expans. of the porcelain was 0.00000379 and that of the cement 0.00001100. This difference in expans. cracked many insulators and a cement having a lower coeff. of expans. was developed. During the war substitutes for English kaolins and ceramic colors were developed. New uses for ceramic materials were introduced, namely, door latches, window clasps, weights, mortar, lamp stands, and so forth. Normal porcelains have a softening point of 1500° C and special porcelains at 1700° C. Marquardt bodies have a softening point of 1850° C and are not considered porcelains because they do not become dense, transparent and white. Other materials which have a high softening point are: alumina 2050° C; silicon carbide, 2500° C, magnesia, 2800° C, zirconium oxide, 2950° C, and boron nitride, over 3000° C. These are not considered porcelains, however, since they do not become dense and transparent when fired at normal temperatures. H. G. SCHURECHT.

Pottery making in Japan. J. F. ABBOTT. *Clay Worker*, **1920**, 596–7, 646.—Japanese pottery may be divided into three classes (1) stoneware in which ornaments are put on the ware by stamping or scoring; (2) faience which has a crackled glaze and is highly decorated. It is not fired as high as porcelain and for this reason may be decorated with more delicate colors, and (3) hard porcelain and semi-porcelain. Kaolin is washed in horizontal washing machines consisting of a barrel-shaped tub filled with water, about 12 ft. long and 6 ft. in diam. Within this barrel is a revolving horizontal shaft to which arms are attached. Sand is deposited in the washer and the finer material is passed through troughs which branches into more troughs, thus decreasing the flow of the slip and allowing the mica and other impurities to settle. The old style glazes are compounded of clay paste with wood ashes of oak and chestnut. The bulk o the Japanese ware is made

in the household, one family making the molds while another does the casting, and so forth. The kilns are usually placed along a hillside, the successive kilns being placed at higher levels than the preceding ones. The heat from one kiln passes through those above operating somewhat like the German Hoffmann kiln. H. G. SCHURECHT.

PATENTS

Casting of pottery and other like articles. B. J. ALLEN AND R. Y. AMES. U. S. 1,336,180, Apr. 6, 1920. Slip casting in porous molds is expedited by surrounding the mold with an enclosed space and reducing the pressure within this space. The water in the slip is thus more quickly drawn through the porous mold. The same result may be produced by introducing the slip under pressure. Walls of varying thickness may be made by varying the thickness of the mold walls, the thinner the mold wall the more rapid the flow of water through it and consequently the greater the thickness of the clay wall which builds up at this point. Large, thick articles such as glass-house pots, retorts, crucibles and the like may be made by this method.

Method of staining glazed ceramic ware. J. W. HASBURG. U. S., 1334,301, Mar. 23, 1920. When it is desired to stain glazed ware, the glaze of which is unsuitable for fire staining, a secondary glaze which is suitable is applied and fired. The stain is applied to the secondary glaze and fired in the usual way.

Method of making sanitary earthenware. E. H. LAWRENCE. U. S. 1,337,663, Apr. 20, 1920. It is a common practice in making closet bowls by slip-casting to cast the bowl and cut away certain parts of the mold to form passageways. According to this invention those parts of the mold corresponding with the passageways are coated with shellac to make them non-absorbent, with the consequence that the slip does not deposit and form a wall at these places.

Method and means for producing saggars. F. J. WOLFF. U. S. 1,337,871, Apr. 20, 1920. The saggar body is expressed in sheet form through a die having the width and thickness desired in the slab produced. This die is lubricated by means of a series of small pipes radially disposed about the condensing nozzle and projecting slightly into the clay, forming grooves. The lubricant is fed into these grooves through the small pipes. The ribbon emerging from the die is cut into desired lengths and made into saggars. A better distribution of the grog is said to result from this method than can be obtained from other machine methods of forming saggars.

G. E. MIDDLETON.

Enamels

Composition of enamels for cast iron. Schnurpfeil's review for glass works. Vol. 3, No. 35, p. 549.

	White	White	Blue	Blue
Feldspar	40	42	46	25
Borax	28	22	21	30
Soda ash	10	13	14	11
Tin oxide	8	8	...	2
Saltpetre	1	..	2	3
Fluorspar	..	5	4	..
Cobalt oxide	..	..	1.75	2
Quartz	..	..	...	17
Cryolite	..	..	...	3

R. J. MONTGOMERY.

Enamel investigations at the Bureau of Standards. STAFF ARTICLE. *Chem. Met. Eng.*, **22**, 810 (1920).—At the request of the Metalware Manufacturers Association of America, the Enameled Metal Division of the American Ceramic Society and a large number of individual manufacturers, the Bureau of Standards is carrying on a comprehensive research in an endeavor to discover the cause or causes of the jumping off of small particles of enamel, which results in the defect known in shop practice as "fish scaling," and the methods of controlling and eliminating it. This investigation was begun in July, 1919, and has been conducted energetically ever since. For several months the Bureau has had in progress an investigation of the relation of composition of enamel to solubility in strong mineral acids. Results so far obtained indicate that some of the commonly accepted conceptions of the relation between composition and acid resistance of enamels are erroneous. Information is being secured, also, in regard to relations of composition to fusibility and to the tendency to chip or to craze, or crack.

A. J. LAMBERT.

Papers on enameling before the Chicago Section, American Ceramic Society. STAFF ARTICLE. *Chem. Met. Eng.*, **22**, 1107 (1920). See *J. Am. Ceram. Soc.* **3**, 522 (1920). A. J. LAMBERT.

PATENTS

Enameling and annealing furnace. P. DUPONT. U. S. 1,335,279, Mar. 30, 1920 The furnace described is particularly designed for the enameling of bath tubs, although it may be modified in shape to be suitable for other articles. It comprises a receptacle conforming in shape to that of a bath tub, the walls of which are lined with a porous refractory. A cover of similar material is provided. A mixture of fuel gas and oxygen is forced through the porous walls and ignited. These walls thus become incandescent and impart their heat to the tub. When the proper temperature has been reached the cover is removed and the enamel sprinkled over the surface of the tub. As the tub is meanwhile being subjected to the furnace heat the powdering can be effected in one operation.

Process for permanently producing picture effects upon enameled metal surfaces. R. SANDBY. U. S. 1,335,755, Apr. 6, 1920. After the enameled

surface to be treated is cleaned, it is coated with a uniform coat of a suitable gum varnish. After the varnish has set the picture is transferred upon it. This is done by first printing the matter to be transferred on transfer paper with printers ink, dusting it evenly with a mixture of metallic oxide and silica and pressing the inked and coated paper upon the varnished surface. The paper is then removed and after the coated surface has dried it is dusted with a low-fusing flux. The whole is then fired. G. E. MIDDLETON.

Brick and Tile

Slag brick. ANON. *Tonind.-Ztg.*, **44**, 582–3 (1920).—Near Berlin alone there are four plants making brick from gaswork slag, which seems well adapted for this purpose. The slag in this vicinity is very hard. The sulphur content in the slag should not be too high and this may often be reduced by certain refining treatments. The slag is crushed to 12 mm. size. At first a mixture of 1:8 was used with cement as a bond, but since 1:10 mixtures have a crushing strength of 35–40 kg./cm., which is amply strong enough for many purposes, this mixture is now used almost exclusively. The batch is thoroughly mixed with water for about 5 mins., when it is fed into molds of a Nestor machine. Each brick receives 5 blows from an electrically driven hammer and 6 brick are made at once. At the end of 14 days they are ready for use. Each slag brick machine makes 500 brick per hour. With 6 machines operating 8 hrs. 22–2400 brick can be made per day using a 16 h. p. motor. H. G. SCHURECHT.

Brick sands. ANON. *Tonind.-Ztg.*, **44**, 529 (1920).—Many so-called brick clays are nothing but sand bonded together with clay. The chemical analysis of 7 materials used for making brick showed that the content of silica in these are as follows: (1) 32.80 per cent, (2) 35.8 per cent, (3) 41.00 per cent, (4) 43.20 per cent, (5) 49.90 per cent, (6) 57.80 per cent, (7) 72.18 per cent. A good many of these should be more properly called sands rather than clays. H. G. SCHURECHT.

Compression strength of loam brick and loam brick masonry. GEBAUER. *Tonind.-Ztg.*, **44**, 301–3 (1920).—Owing to the shortage of coal in Germany a large number of clay brick are used in the unburned state. To compare these brick with fired brick compression strength tests were run on air dried specimens and also on masonry consisting of three to eight brick placed upon each other to form a column. The following results were obtained:

		After 4 weeks storage in contact with moist air	
Manner of making	Compression strength, kg./cm.²	Water absorption, per cent	Compression strength, kg./cm.²
Machine.....	42.3	1.09	27.2
Machine.....	34.9	1.02	21.1
Hand.....	30.9	1.12	21.3
Hand.....	26.1	0.76	20.1

Tests made on columns of three brick gave compression strengths varying from 9.0 to 37.1 kg./cm². First class fired clay brick must have a compression strength of 150 kg./cm.², and second class brick must have a compression strength of 100 kg./cm². It is, therefore, obvious that the unfired brick do not meet these requirements and, therefore, should only be used to support light loads. When in contact with damp soil and rain the brick readily disintegrate and, therefore, must be protected from these sources of moisture. Since the cost of the brick is only a small part of the total cost of a house the saving due to using unburned brick is very small. After the coal again becomes plentiful it is predicted that burned brick will take the place of the unburned brick. H. G. SCHURECHT.

Bricks, preventable defects in refractory. C. E. NESBITT AND M. L. BELL. *Proc. Am. Soc. Testing Materials*, **19**, Part II, 620–9; see *J. Am. Ceram. Soc.* **3**, 330 (1920). A. J. LAMBERT.

PATENTS

Method and means for setting brick mechanically in kilns and the like. W. W. DICKSON, JR. U. S. 1,334,892, Mar. 23, 1920. This invention relates to a device for setting bricks mechanically. The brick to be set are placed upon a pallet, the pallet lifted by a metallic support carried by a traveling crane and moved to the spot where the bricks are to be set. The pallet and its support are then tipped and withdrawn allowing the bricks to slide off into position.

Brick machine. O. J. MOUSETTE. U. S. 1,335,071, Mar. 30, 1920. This is a type of machine which comprises an intermittently rotated mold table, a plunger for compressing the material in the molds, an endless carrier in feeding pallets into position for receiving the bricks and delivering them from the machine, and an ejector for dislodging the bricks from the molds.

Brick-handling and setting apparatus. G. E. LUCE. U. S. 1,335,344, Mar. 30, 1920. This invention relates to a machine for handling green, dry and burned brick in a pile or unit stacked relation. One of the improvements relates to means for setting the benches between the arches of a kiln. G. E. MIDDLETON.

Abrasives

PATENTS

Abrasive wheel. S. C. LINBARGER. U. S. 1,336,751, Apr. 13, 1920. In order to obviate the radial cracking which often occurs around the arbor hole of abrasive wheels, that part of the wheel adjacent the arbor hole is made less dense than other parts of the wheel. The same bond is used throughout, but the central part of the wheel is made less dense by the use of a greater percentage of coarser abrasive grains in the central portion.
G. E. MIDDLETON.

Cement and Lime

Enemies of cement. ANON. *Tonind.-Ztg.*, **44**, 593 (1920).—The destructive agents occurring in cement are uncombined lime, magnesia, and gypsum. In cements made from blast furnace slags manganese and sulphides often cause trouble. Destructive agents which attack the cement from the outside are acid waters, magnesia salts in sea water, sulphuric acid of swamps, carbonic acid in water and certain fatty oils which penetrate the cement and form lime soaps with the lime thereby destroying the cement.

Heretofore remedies for all these evils with the exception of the oil have been used successfully. A cure for the oil trouble has been recently developed by a German concern which has proved very successful.

H. G. SCHURECHT.

Iron cement ships. ANON. *Tonind.-Ztg.*, **44**, 344 (1920).—Ships of cement have been built in Norway and Sweden. These ships behave satisfactory in storms with the exception that water is thrown over the low free board line. By the use of light weight aggregates the density of the concrete may be decreased from 2100 kg. to 1500 kg./cm³. which would raise the free board line higher above the water. A cement ship "Askelad" was recently stranded upon St. Quentin. After pumping out the water the ship was all right with the exception of the loss of some machinery. An iron ship was stranded here and wrecked, showing that cement ships can withstand rougher treatment than the iron ships. H. G. SCHURECHT.

Cement balls for ball mills. ANON. *Tonind.-Ztg.*, **44**, 411 (1920).—Pieces of cement clinker were broken to sizes slightly larger than pebbles used in ball mills. They were then put in the mills together with a charge and after grinding became smooth, making excellent substitutes for flint pebbles.

H. G. SCHURECHT.

Bricks for lining rotary kilns. ANON. *Brit. Clayworker*, **29**, 9 (1920).—In rotary kilns used for firing cement there are three zones in which it is desirable to employ different classes of brick. The first or charging zone should be very resistant to abrasion but a high degree of refractoriness is not necessary. The second or fluxing zone is subjected to the high temps. and should be lined with aluminous material containing not less than 35 per cent alumina and having a softening point of at least cone 32. Bricks made of fused alumina give best results in this zone. To prevent heat losses the lining should be surrounded by a porous insulating brick. A mixture of burned cement and raw cement are sometimes used in the place of brick. Magnesite brick are too sensitive to sudden temp. changes and chrome brick are too expensive. Carbon brick can not be used because of the oxidizing atmosphere. Silica and carborundum brick are destroyed too quickly by the action of cement. For the third or cooling zone, brick which are very re-

sistent to sudden temp. change should be used. Fire-clay brick rich in alumina and being dense are desirable. H. G. SCHURECHT.

Cement in 1918. E. F. BURCHARD, *et al. U. S. G. S. Min. Res.*, **1918**, Pt. II: 25, Apr. 9, 1920. Interesting data and tables of statistics covering the domestic and foreign cement industry are given in this report.

E. D. ELSTON.

Process for manufacturing of insulating bodies from basic magnesium-carbonate and fibers. Ger. pats. 303,310 issued 8/11/19 and 304,239, C, 1920, Lipsia Chemical Works.—Basic magnesium carbonate is precipitated from solution on mineral, vegetable or animal fibers. The magnesium sol. is filtered through the form and allowed to impregnate same. It is advantageous to carry out the process in two stages by first precipitating magnesium carbonate and after decanting the mother liquor transforming the precipitate into basic magnesium carbonate by boiling with water. Shapes so produced are much lighter than those obtained by pressing in a form.

H. G. SCHURECHT.

PATENT

Cement. G. WITTY. U. S. 1,336,178, Apr. 6, 1920. A cement composition consisting of clay, finely divided rock, yellow dextrin, barium sulphate and barite.

Artificial stone for roofing. C. B. AYERS. U. S. 1,335,038, Mar. 30, 1920. A composition comprising lime, asbestos fiber, soapstone and silex adapted to be made into sheets.

ACTIVITIES OF THE SOCIETY

New Members Received during May

Associate

Brennan, George L., 5 N. Carey St., Baltimore, Md., Supt., Chesapeake Terra Cotta Co.

Castro Oliveira, Rodolfo, Box 188, Alfred, N. Y., Student, New York State School of Ceramics.

Crownover, A. W., Factory Manager, Maryland Glass Corporation, Mount Winans, Md.

Donahoe, Frederic W., 840 Oliver Bldg., Pittsburgh, Pa., Secretary, The Refractories Manufacturers Association.

Hartford, Frank M., Box 145, Abingdon, Ill., Supt., Kiln Construction, Abingdon Sanitary Mfg. Co.

Hodges, R. T., 303 Railway Exchange, Chicago, Ill., Magnus Co.

Huisken, H. A., 6720 St. Lawrence Ave., Chicago, Ill., Student, University of Illinois.

Inman, G. E., Development Engineer, Lamp Development Laboratory, Nela Park, Cleveland, Ohio.

Lindmueller, Charles, Supt., Metal & Thermit Corporation, East Chicago, Ind.

Ogden, D. P., Engineer, Streator Brick Co., Streator, Ill.

Robinson, J. D., President, Libbey Glass Mfg. Co., Toledo, Ohio.

Stockdale, V. B., 609 W. Meek St., Abingdon, Ill., Supt. Abingdon Sanitary Mfg. Co.

Tyler, H. B., 216 Gibson St., Canandaigua, N. Y., Supt., Enamel Department, Lisk Mfg. Co.

Foreign Associate

Laird, Clinton N., Professor of Chemistry, Canton Christian College, Canton, China.

Mackie, I. C., Dominion Iron & Steel Co., Sydney, Nova Scotia.

Satoh, Shinzo, Engineer, Tokio Electric Co., Kawasaki, Kanagawaken, Japan.

Corporation

Bush, W. G., & Co., 174 Third Ave. North, Nashville, Tenn.

Important Actions of the Board of Trustees

June 9. It was voted to accept Mr. R. C. Purdy's resignation as chairman of the Committee on Sections and Divisions.

June 9. It was voted to authorize the chairman of the Committee on Publications to render expense accounts for postage, stenographic services,

and travel in soliciting advertisements for the Journal, the sum of not more than $400.00 to cover such expenses up to the next annual meeting.

June 9. It was voted that the price of the Collective Index to the Transactions be one dollar.

June 22. It was voted that the Glass Division be asked to nominate a person who shall act as official representative of the American Ceramic Society and escort to the party from the Society of Glass Technology, of England, on their trip to glass plants in America, the expenses of such a representative to be paid by the American Ceramic Society.

Special Meeting of the Enamel Division at Washington, D. C., June 15, 16, 1920

The Enamel Division held a joint conference with the Sheet Metal Ware Manufacturers Association at the U. S. Bureau of Standards, Washington, D. C., on June 15 and 16. The results of the investigation on fish scaling of sheet steel enamels were presented at the meeting before forty-five representatives of various enameling firms and interests from all sections of the country. This was the first special meeting of the Division ever called and the attendance and the interest manifested were very gratifying.

Preceeding the presentation of the report on the investigation of fish scaling two papers on enamels were read. These consisted of a paper on "Cast Iron Enameling" by H. L. Menne, and one on "The Preparation of Sheet Steel for Enameling" by L. G. Whitford. These papers were originally presented at a meeting of the Chicago Section.

A report of the meteing will be mailed at an early date to all members of the Division. It is the desire of Chairman Poste to hold a division meeting during the summer session in Chicago to bring out developments of the various investigations being conducted by members of the Division, and it is hoped that the attendance will equal that at this special session at Washington.

R. R. DANIELSON,
Secretary.

A Letter From the President

The following letter from Mr. Minton to the Secretary is thought to be so interesting that all the members of the Society should see it.

DUSSELDORF, GERMANY, June 10, 1920.

MY DEAR PROF. BINNS:

Have been trying for some time to get a letter off to you, but it seems I have little time left when my schedule is completed and I have written to my wife and sent out a few postcards.

I left Berlin last Monday A. M. and came through to Wesel. Was busy there in a plant until noon today, when I came to Dusseldorf. Tomorrow I spend in a plant at Rotingen near here. Saturday I go to Cologne, where I meet Carl Griffin and Bob Anderson of the Norton Co. Sunday I expect

to take the famous ride up the Rhine. On Monday I shall see the Norton plant and Tuesday leave for Leipzig where I shall spend a couple of days. Then on to Bau Elster, a bathing place, where I shall spend four or five days with friends. I then go to Dresden and Meissen, where I see some porcelain and sanitary plants. Then down to Selb to see the famous Rothenthal Porcelain Works, the largest in Germany. Expect also to see a plant making doll heads. Then go to Altwasser to see a new tunnel kiln and on to Münsterburg to see the largest sewer pipe plant in Germany. Then I go to Breslau and then on to Berlin. Have several one-day trips of inspection from Berlin and shall leave about July the tenth for England.

Have already visited a number of plants and have found some things of great interest. Have been especially interested in the plants making stove-tiles, something quite new to me. The Royal (now Staatlicher) Porcelain Works at Berlin was very interesting. Dr. Rieki, the director, was very much interested in getting our transactions from 1914 to 1920, as he was unable to get them from 1914 on. On account of the adverse rate of exchange it is impossible for the Germans to renew membership in the A. C. S. I have thought we might send Dr. Rieki a set in exchange for a complete file of Sprechsaal and Cheramischer Bund., which might be of value to our abstractors.

Conditions in Germany are very bad. As long as I am in the good hotels in the larger cities I can get all I need, although it is expensive. But in the smaller cities and towns the food is very bad and many things cannot be had. Two weeks ago I spent ten days down in a small town near Dresden and could not have stayed except for food I took along. Sugar, butter, milk, meat and fresh fruits simply could not be bought and the bread is almost uneatable. Today I had the only good bread I have had since coming into Germany. I am getting very tired of the poor food and lack of variety. Potatoes are about the only vegetable, although garden truck is now coming in. I have forgotten what a steak looks and tastes like.

All the ceramic plants are working as full as they can, but not up to production on account of lack of coal. I must confess I am not optimistic on the future of Germany. I do not see how they can continue to work and produce unless they have food. It would not surprise me to see Bolshevism in Eastern and Southern Germany this winter.

Traveling is very trying. The trains are all gone to pieces, the cars are dilapidated and dirty, and the tracks are uneven. Germany is surely all shot to pieces. They went until the last match was burned. I really do not see how the people could be made to endure the war so long. It seems to me that no other people would have done so.

Have heard nothing from America since I left, but I trust the A. C. S. matters are being pushed along well and that new members are coming in and advertisements are placed.

Give my regards to all members of the Board.

Sincerely yours,

(Signed) R. H. MINTON.

Necrology

George F. Young.—With the death of George F. Young, the American Ceramic Society and the ceramic industries of this country lost one of their most striking figures. Mr. Young was actively identified with the industrial life of Zanesville, Ohio, for nearly a quarter of a century. He was at the head of The Roseville Pottery Company, which from its incipiency was under his guidance. Beginning in a small way at Roseville, Ohio, he built up one of the greatest ceramic manufacturing concerns in Ohio, and at the time of his death was its manager and treasurer. Many years ago the business was moved to Zanesville and a consolidation of all its subsidiaries effected.

Mr. Young was a man of tireless energy, keen perception, and steadfast adherence to purpose. He was a genius in the matter of detail, and up until the very last kept in close touch with his business, which will be a lasting monument to his ability and energy.

Plans for Summer Meeting

Plans for the Summer Meeting are rapidly materializing. The meeting will occur in Chicago and the dates will be August 16–18 both inclusive. Headquarters will be at the Hotel La Salle, and the following plants will probably be visited: The Northwestern Terra Cotta Company, The Bach Brick Company, The Lindsay Light Company, The Coonley Manufacturing Company, The Western Electric Company, and the Fansteel Products Company. Others will be added to the list. The programs will be issued in good time. Fred B. Ortman, Northwestern Terra Cotta Company, is chairman of the Summer Meeting Committee.

Plans for Ceramic Day at the Exposition of Chemical Industries are also maturing. Friday, September 24th, has been selected as the day. The program is in the hands of the Committee on Coöperation. Mr. H. Schmidt, Roessler and Hasslacher Chemical Company, is chairman of the local committee.

Meeting of the New England Section

A meeting was held in Worcester, Mass., June 12, 1920. During the afternoon an inspection was made of a fine collection of early American pottery. Dinner was served at the Norton Boat Club and eighteen members were in attendance.

A paper on "Fuel Oil Burners for Tank Glass Furnaces" was given by Mr. Browne Harding of the Providence Base Works of the General Electric Co. This was very interesting and was followed by quite a general discussion.

M. C. Booze, *Secretary*

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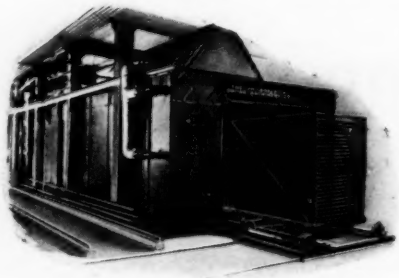

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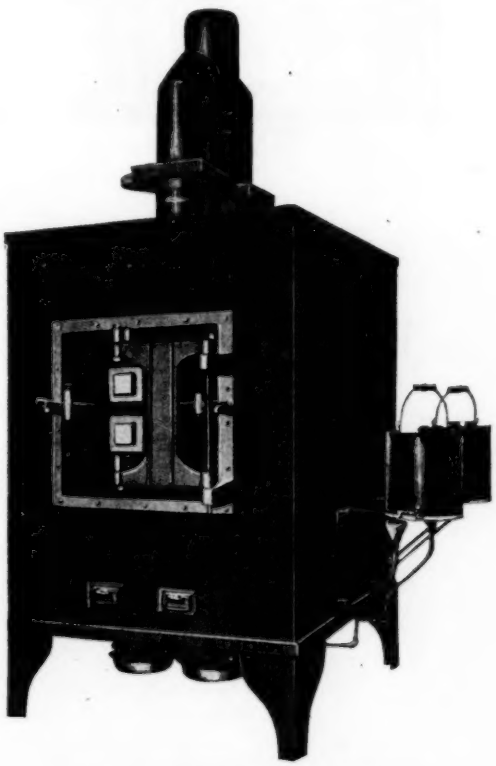

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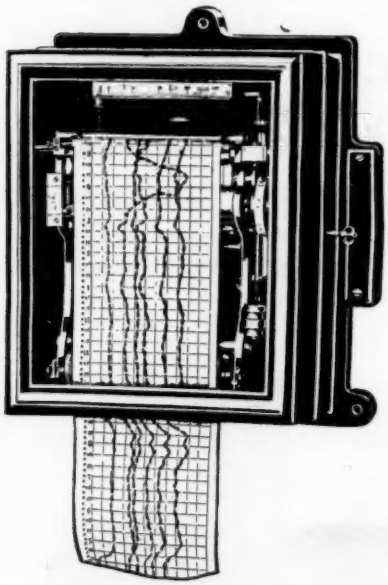

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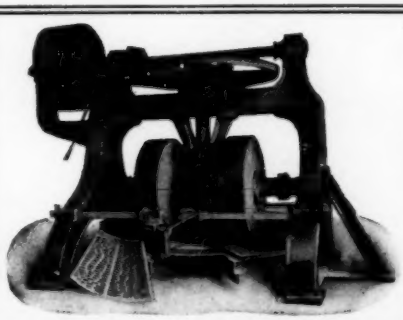

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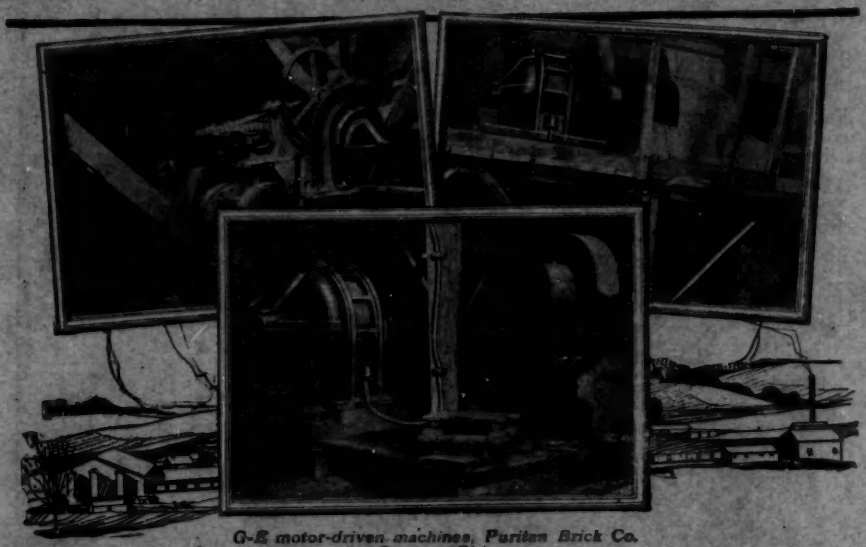

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